Managing image data in aquatic sciences: an introduction to best practices and workflows

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ABSTRACT

Nozères, C. 2011. Managing image data for aquatic sciences: an introduction to best practices and workflows. Can. Tech. Rep. Fish. Aquat. Sci. 2962: xii + 171 pp.

An overview of digital photo and video technologies is presented for the capture and management of image data in aquatic science projects. Digital still images (photos) and digital video technologies are evaluated for current practices and standards in terms of media files, equipment, and workflows. Case examples of science work and several software packages are provided as suggestions for improving the quality of images and for efficient data management.

RÉSUMÉ

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Un aperçu des technologies numériques en photo et en vidéo est présenté pour l'acquisition et la gestion des données d'imagerie dans le contexte de projets en sciences aquatiques. Les technologies pour les images fixes (photos) et la vidéo sont évaluées en fonction des pratiques courantes et des normes en matière de média, d'équipement et de flux de traitement. Des exemples de scénarios de travail employant une variété de logiciels sont fournis à titre indicatif pour améliorer la qualité des images et pour une gestion efficace des données associées.

PREFACE

In 2006, the National Science Data Management Committee (NSDMC) put forth a strategy for dealing with the overall management of scientific data within DFO. The main strategy topics are 1) archiving of data, 2) access to data and information, 3) standards and their application to managing data, and 4) governance.

In 2009, the NSDMC created the National Image Data Management (NIDM) working group that is responsible for the development, implementation, and communication of a national image data management strategy for DFO Science. This strategy addresses the same four topics as they relate to the handling of image data. For these purposes, image data is defined as any image or series of images acquired through photographic or videographic means and held either in analogue or digital form.

In 2010, as part of the task of developing the strategy, the NIDM commissioned a "Best Practices" image data guide. The guide would serve as a general review of current standards and practices for aquatic science imaging work, along with recommendations of useful procedures and tools. To ensure the public availability of this guide, it is being made available as this Technical Report.

1. INTRODUCTION

1.1. Purpose of the guide

This guide is meant to assist workers in the aquatic sciences to produce and manage image data by presenting general information and specific examples of best practices. Image data here is meant to represent all forms of optical imagery, from still images (photographs) to moving images (film and video). The emphasis is on original digital media, while also covering the digitization of analogue media (celluloid film, magnetic tape, and paper prints).

There is no shortage of excellent guides and training workshops for digital photography and filming, but for the most part, instruction is oriented towards obtaining the highest quality in producing files for commercial or aesthetic goals. Image quality is not a feature to be ignored for science work, but more often the challenges of time and resources result in fewer images obtained and of possibly lesser value, especially when images are viewed as a casual addition to other data-gathering activities, for example, taking photos in the lab or in the field. On these occasions, images and videos may appear of little consequence or even as a distraction, slowing down the work activity. With some preparation during and after the shooting of images or videos, the editing and managing of this image data becomes less of a burden and increases in value. Having image data produced with less effort and easier to use (i.e., by being tagged to make them easier to find and organize) will increase the chances that more and better image data will become available for use in science.

For most casual projects, the guide will serve to introduce or review the image formats, standards, and metadata for scientific goals. Major projects that make explicit use of image data, such as underwater and aerial imaging surveys, are likely to be already familiar with many of these concepts, although they will also benefit from the presentation of alternative approaches and examples presented (Fig. 1).
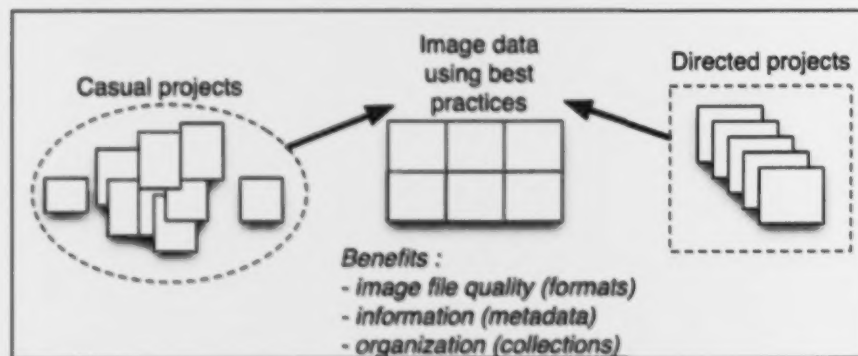
Figure 1. Best practices may help with both casual and directed image data projects.

1.2. What to expect in the guide

Working with image data is a broad subject, and only certain aspects will be covered in this first edition of a best practices guide (Fig. 2). The reader can therefore expect to find a general overview of several aspects of image data processing and organization (Section 2), equipment (Section 3), and workflows (Section 4). This is followed by a series of examples that may be encountered during science work activities at DFO (Section 5). As a number of work examples are dependent on specific tasks using certain software, a series of software work examples are also presented (Section 6). Finally, some discussion is presented regarding distributing image data (Section 7). Appendices with extra information are also included as reference sheets.

Please note that every effort has been made to provide timely and correct information; however this report is not intended as an authoritative or reference document. The reader is encouraged to use the information here as a starting point, taking into account the particular needs for their project and changes in technology. Finally, while several commercial tools are named in the concepts and work examples in the guide, this does not constitute an endorsement of these products or their companies.
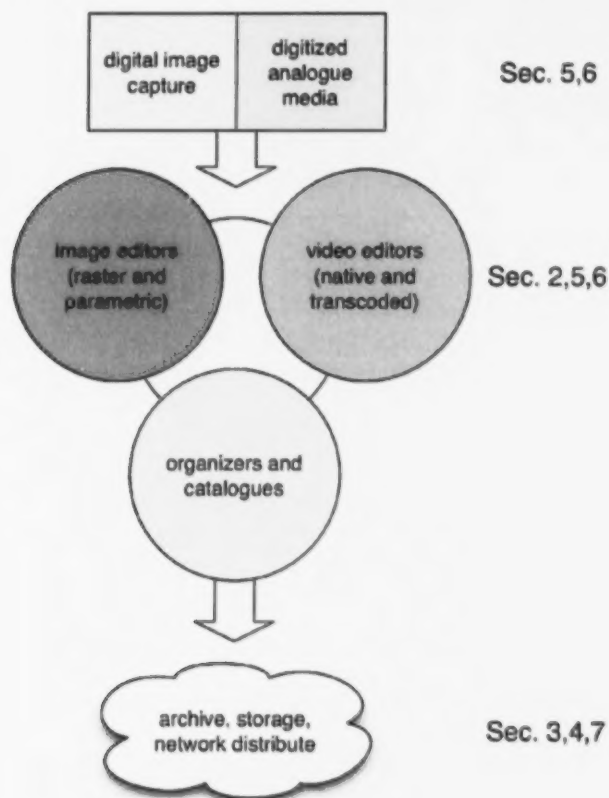
Figure 2. Topics and work steps to be covered in the guide.

2. IMAGE DATA

2.1. Managing digital assets

Digital asset management is a system for handling image and video files. At the outset, there are considerations of file formats and the metadata related to those files (Fig. 3 [1, 2]). Metadata, or the associated information, is either directly part of the image data file or contained in related datasets. Work with both takes place during file editing (Fig. 3 [3]) and in organizing file catalogs or collections (Fig. 3 [4]).
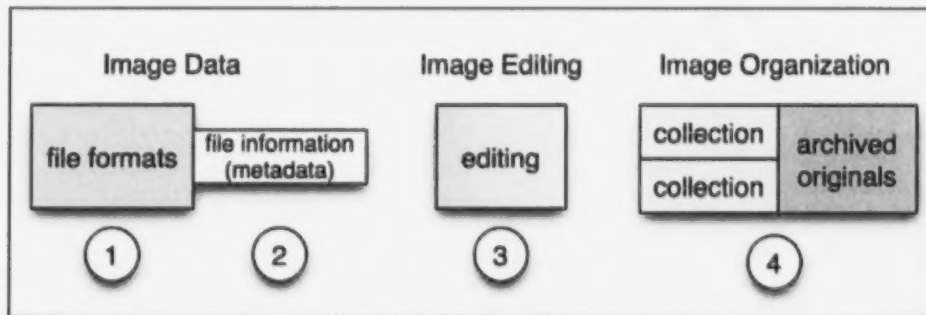
Figure 3. Digital asset management as a system to work with image data.

2.2. Image data: formats and standards

It is helpful to distinguish between file types and uses when discussing image formats. In terms of usage, formats may be associated with stages in a workflow (Fig. 4). These may be grouped as:

Acquisition format (capture from a source)
- initial data may be in a raw format, but most often are pre-processed (with data loss, e.g., JPG image, MPEG-2 video codec)

Editing (intermediate) format
- convenient for processing (computer responsiveness)
- without data loss ("lossless", e.g., TIF image, Lagarith video codec)

Distribution formats
- compressed data (often with loss), producing reduced-size files for viewing
- may have preview + master in archives (e.g., JPG + TIF, RAW, or DNG)
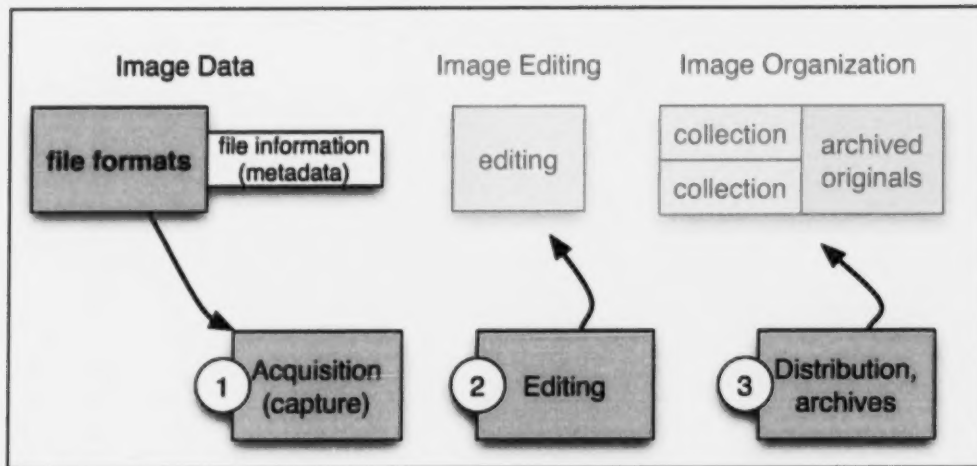
Figure 4. Categories of file formats: (1) acquisition, (2) editing, and (3) distribution.

At these different stages, the ability to select or work with different formats may depend on equipment decisions. This is an important consideration when trying to adopt the "best format" for image data. For example, in the case of most consumer photo cameras, file capture is only available as JPG. Similarly, many video cameras currently use DVD and AVCHD recording. In these two cases, the source data has been captured in formats that will influence the subsequent stages in editing and distribution.

Image data formats are commonly named and described somewhat differently for still images (photos) than they are for moving images or video (Fig. 5). With video, the main challenge is to compress a sequence of still images, along with the accompanying audio and metadata, for an "acceptable" viewing experience in terms of image quality and smooth file playback. The technical solutions that have been developed to accomplish these tasks are daunting in their complexity and only the most general aspects will be discussed in the present guide.
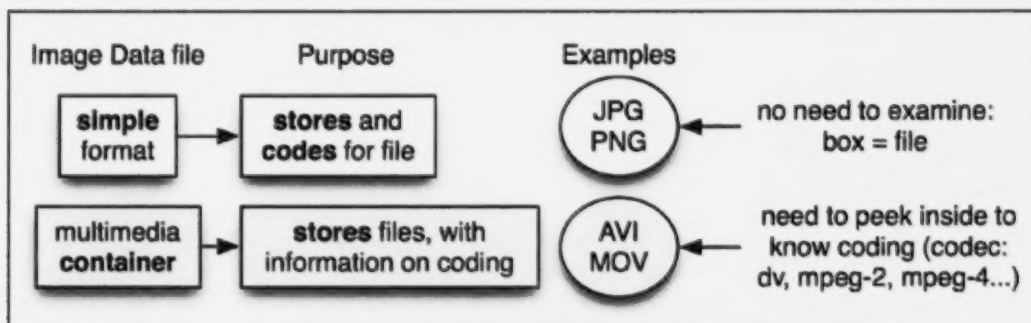
Figure 5. Explaining image file formats as boxes holding data.

Compared with video, still image (photo) data is relatively straightforward to explain and understand (Fig. 6), with differences in formats based on:

- *image potential* (quality)
- *image information* (metadata)
- *image access* (compatibility)
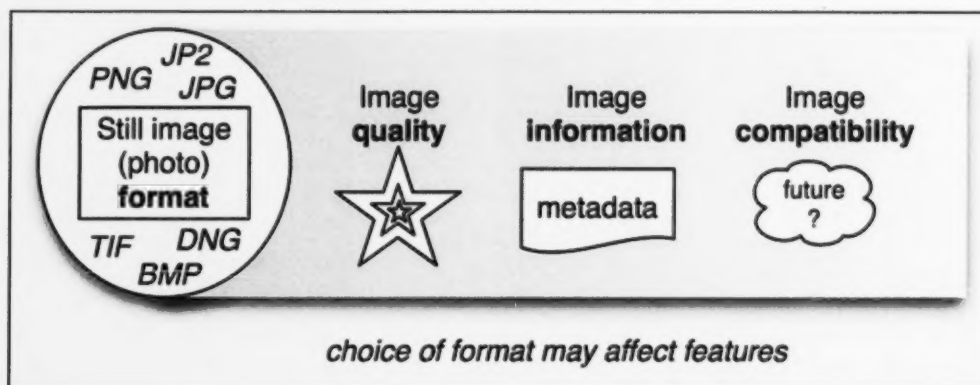
Figure 6. Still image formats vary in image quality, information, and compatibility.

Image potential is the capacity to retain information from the visual scene being imaged. For example, photo formats vary in their depth of colour information (standard or wide profiles) and shade levels (dynamic range and bit-level).

Image information is the capacity to read and write details of the capture (metadata) into the file. The standardization of the information written will have an impact on image access, i.e., the ease with which a format can be opened (read) correctly by software.

Image access, or comptability, is an issue of concern for science work and will be discussed in Section 4 on archiving and "futureproofing."

2.2.1. Photo formats

Digital photos, or still images, may be associated with a wide range of file formats, some of which apply to technologies that are no longer available such as Kodak PhotoCD or Scitex. A summary of currently popular formats for image files is listed in Table 1.

Table 1. Common digital still image (photo) formats.

Name	Format	Source	Comments
JPG	JPEG – basic photo	Basic still camera	• frequently the original images • contains EXIF and XMP metadata
RAW	NEF (Nikon), CR2 (Canon), etc.	Advanced still cameras	• raw image file with a JPG thumbnail • also has text file of metadata: XMP
DNG	raw image + JPG preview + XMP	Converted from raw (NEF, CR2, etc.)	• raw file in a standardized container (as compared to proprietary raw file)
TIF	tagged image file format (TIFF)	Digital microscope or scanner	• 16-bit image possible (JPG is 8-bit) • for edited photos and archives
PSD	Photoshop document	Editing software	• working files with Photoshop adjustment layers (not archives)
PNG	portable network graphics	Screenshots, editing software	• lossless photos for docs and web • no EXIF or XMP metadata
JP2	JPEG 2000 – for technical situations	Geospatial imagery and digitization projects	• rare (photos use DNG, TIF, JPG) • used in cinema: MJPEG2000 • no EXIF or XMP metadata
BMP	Windows bitmap picture	Older scanners and screenshots	• outdated – use JPG, TIF, PNG • no EXIF or XMP metadata

Among these standard formats, image capture is usually in the form of JPG, with advanced equipment offering the option of TIF or RAW capture. An overview of the main advantages and benefits of each of these formats is presented below. Note that some files have functional limits (such as editing RAW) and may make use of a special data file i.e., the XMP "sidecar." The XMP may be embedded or external to an image file. The purpose of XMP among image formats is summarized in Fig. 7.

Figure 7. Role of XMP as embedded or external data for the image file.

Features of JPG

As the most common file type from digital cameras, JPG is widely compatible with software. This format is 8-bit, giving 256 levels, or steps, for each channel. Thus colour images have 24-bit depth, with 8 bits each for red, green, and blue. By comparison, other formats may offer 10-, 12-, or 16-bit channels, storing many times more information at thousands of levels, which becomes invaluable during edits for recovering detail in shadows and highlights. Of the image formats presented here, JPG is the only one that is lossy: image data is discarded in the compression with each new save of the JPG file. As a consequence, original JPGs should be preserved (archived) and editing should be performed on copies (with new names).

Recommended use: original camera images (archive before editing).

Features of TIF

Image data stored as TIF is conserved without loss, but this leads to very large file sizes when compared to JPG files. Now that RAW images are easy to process with fast computers, the option to save files as large TIFs for higher quality is rarely used. Exceptions are seen with some scanners and digital microscopes that send their files directly for storage on computer drives. The principal reasons to use TIF as a capture format instead of JPG is to retain fine detail (i.e., detailed documents scans) or to capture a wider range of shading and colour information (16-bit). TIF is often used as an editing format, such as mosaics and panoramas obtained from several JPGs, and for storage as an archival format. Regular TIF files are very large, but lossless compression is available. LZW compression is popular and compatible with many systems.

Recommended use: image scans (if available), storage of edited photos.

Features of PSD

Photoshop documents are used in specialized image editing involving layers, stacks, text, and composition tools, for both 8- and 16-bit files. Compatibility and large size can be issues with these files; if the edit work layers are no longer needed, the file could be converted to TIF (16-bit, layers, non-lossy) or JPG (8-bit, no layers).

Recommended use: working copies of advanced image edits.

Features of PNG

As a popular alternative to TIF, JPG, GIF, or BMP, the PNG format is best suited for illustrations because the lossless compression preserves fine detail (unlike JPG). It is used in documents and web sites for clear graphics and photos that use transparency (unlike JPG, GIF). While the standard for PNG was developed to allow the embedding of metadata, reading and writing of "photo data" (EXIF, IPTC, XMP) is unreliable and not often used with this format (unlike JPG, TIF).

Recommended use: distributed versions of images, graphics with fine lines.

Features of RAW (including DNG)

Advanced cameras provide the option of capturing RAW image data as an alternative, or in addition to the JPG file. Essentially, "raw" formats are sensor data "dumps" from different manufacturers. Initially, reading and working with RAW images was difficult for equipment and software because of the need for standards to interpret and for processing power to "develop" the files. Currently, most computer systems handle RAW images natively or with widely available plugins. Capturing in RAW enables much more image data to be preserved in colour and light levels (10, 12, 14 or more bits), but also to some extent in detail because of lossless compression. Editing RAW images is also lossless and applies no changes to the original file since edits are saved into a separate file (XMP) as a set of instructions. In this way, RAW is more conservative than JPG or even TIF (lossless, but the original can be altered). Because the editing instructions and metadata (apart from EXIF) are held in the XMP (a text file), this "sidecar" XMP file must always accompany the "main" RAW file. Adobe's Digital Negative or DNG is a special, generic type of RAW file that makes it easier to open in different software and easier to transport as it hold both the RAW image and XMP together in a single file.

Recommended use: original camera images (archive or convert to DNG).

Features of JP2

The JPEG2000 format (JP2) was designed to overcome some of the pitfalls of JPG by offering the option of lossless compression, higher bit-depth, and advanced metadata (i.e., XML-based geospatial data, or GML). In a practical sense, these advantages have not been adopted in photography, possibly because the use of RAW (and its standardized container as DNG) has become widespread. A number of image software packages are incompatible with reading and writing the JP2 format, even for metadata purposes (i.e., EXIF, XMP). This format is now used mostly in special data collections. Principal examples are collections of geospatial work and image document archives (e.g., Biodiversity Heritage Library, Internet Archive) where the efficient storage of a vast number of files is a priority over the individual management and editing of photos.

Recommended use: collections of geospatial images and digital library scans.

Features of BMP

Although BMP is still encountered with legacy imaging systems such as microscope cameras and scanners, it is not recommended for storing image data because lossless compression and standard photo metadata is uncommon when using this format. Capture in JPG, RAW, or TIF is preferred. Original BMP captures should be converted to reduce file size and to allow compatibility with photo metadata based in IPTC-XMP.

Recommended use: convert to another format such as TIF, PNG, or JPG.

2.2.2. Video formats

Compared to photo files, explaining video formats is more complex, with much confusion over technical acronyms and trademarks. In aquatic sciences, video capture encompasses a wide range of activities, from digitizing celluloid film and videotape data to filming in standard and high-definition video, and beyond. With files on computers, the user notices names like AVI or MPG, which are containers or "wrappers" to package the image data and its metadata. The moving image data itself are conserved using a compression–**dec**ompression algorithm, or "**codec**," which defines the image quality in a sequence. To ensure quality and efficiency when working with video, the video container and codec should be identified. A summary of video containers is shown in Table 2, followed by a list of popular codecs in Table 3. Note that video picture size is commonly referred to as SD (standard TV: 480 pixels vertically) or HD (high definition TV: either 720 or 1080 pixels vertically). See sec. 2.2.3 for a discussion of frame sizes.

Table 2. Summary of moving image (video) container formats.

Name	Format contents	Comments
AVI (.avi)	generic video container on Windows (contains legacy or current codecs)	• popular in advanced video capture/editing • common in distribution (file-sharing) • may require installation of legacy codecs
ASF (.wmv)	ASF stream container with Windows media	• popular for compressed distribution (web) • container accepts digital rights metadata
QT (.mov)	QuickTime-based container (contains legacy or new codecs)	• popular in advanced video capture/editing • accepts advanced metadata (XMP, GPS) • may require installation of QuickTime software
MP4 (.mp4)	mpeg-4 container (contains mpeg-4)	• highly compressed video capture • popular for compressed distribution (web)
.mpg .vob	mpeg-2 program stream (contains mpeg-2)	• basic streams on disk • common in distribution (DVD)
.m2t .mts .m2ts	mpeg-2 transport stream (containing mpeg-2 or mpeg-4 codecs)	• capture: HDV (mpeg-2), AVCHD (mpeg-4) • popular formats for HD video capture • accepts metadata (GPS) in proprietary tools • distribute as Blu-ray disk, HD broadcasts
MKV (.mkv)	alternative to avi, mov, mpeg-4, flash	• open source, versatile (codecs, audio, subtitles, etc.) • popular in file sharing internationally
MJ2 (.mj2)	container for motion-jpeg2000 codec	• sequence of JPG2000 images • proposed archival format for digital video
MXF (.mxf)	material exchange format (container for specialty codecs)	• streams for professional video capture/edit • may be developed into part of CinemaDNG (possible future archival format)
Flash (.flv)	usually part of web page - file is not read alone	• currently popular on web (YouTube) • future uncertain, to be replaced by others
WebM (.webm)	mkv-based project in development by Google	• future web use (HTML5) instead of Flash • open-source alternative to mpeg-4 h.264

Table 3. Summary of common video codecs.

Codec groups	Container examples	Stage of use (shaded = common or preferred use)		
		Capture	Edit	Distribution
WMV (WMV-9, VC-1)	wmv, avi	• slideshows • screencasts	need to convert	• web clips • file sharing
DV, DVCAM, DVCPRO, Digital8	avi, mov, mxf	• legacy and pro • SD and HD • digitized VHS	easy	• archive VHS, DV • broadcast work • large file sizes
MPEG-2 (DVD, HDV)	m2t (Blu-ray), mts, mpg, vob (DVD), mxf	• legacy and pro • SD and HD • digitized VHS	native or convert	• high-quality • DVD • broadcast
Motion-JPEG (MJPEG)	avi, mov	• photo cameras • option on new • SD and HD	easy	• archive format for short clips (large file sizes)
M-JPEG2000	mj2, mov	• digital cinema • HD and beyond	easy	• archive SD, HD • efficient file sizes
MPEG-4 (DivX, H.264, AVCHD)	avi, mp4, m4v, mov, mkv, m2ts	• low- and high-end video • SD and HD	need to convert	• long web clips (efficient format) • modern devices
Cineform		• edit codec • convert source	HD work "lossless"	• intermediate • very large files
Flash	flv, swf	• slideshows • screencasts	need to convert	• web clips for viewing on standard computers

As with still images, the choice of video container may be dependent on the available equipment, from video clips as AVI or MOV, to folders of video streams on DVDs. Scientists seeking to optimize and conserve data quality need to select among a variety of video codecs and their compression settings. To assist with this selection, an overview of the main differences in consumer video codecs is presented below.

WMV
Windows media video is the default codec and media container (although the AVI container may also be used) on Windows systems for viewing and editing basic video. Recent versions (i.e., VC-1 or WMV-9) are very efficient at balancing small file size and high image quality. This makes it suitable for distribution as computer clips or on the web, and as part of the Blu-ray standard. When WMV are exported for computer use, clips can be resized from small screens to HD-sized videos (720 pixels and higher).

Recommended use: computer clips for email and presentations.

DV (DV25)
Part of a large family of DV codecs, the consumer codec DV25 is more popularly known as miniDV for the compact cassettes once used in camcorders. While DV was a marked improvement over VHS, this standard definition codec has now been largely replaced

by HD codecs of MPEG-2 and MPEG-4. The video is wrapped in an AVI container on Windows systems and in MOV on Macintosh systems. In addition to being a popular capture codec for standard definition (720 x 480 pixels) video, DV is also a good editing codec because it retains individual video frames as captured, making it easy to browse, edit, and freeze frame-by-frame (Fig. 8). Conserving all frames has a disadvantage of producing relatively large files per hour of video (13 GB, or several times more than MPEG-compressed files). Hard drive storage was an issue in the past, but with current capacities and low-costs, it is reasonable to retain the original captures and edits in archives as DV-AVI without needing to compress these files.

Recommended use: legacy capture (standard definition), editing, and archiving.
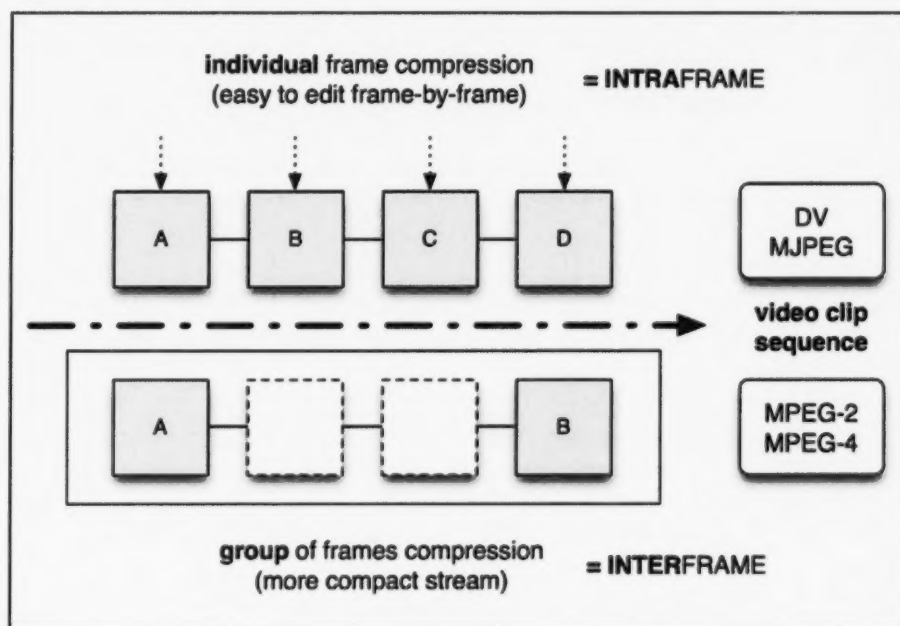
Figure 8. Comparing frame- and group-based compression for video codecs.

MPEG-2

This is a broad group of codecs for SD and HD video. Previously, when storage costs were high, this group was an important successor to DV by enabling SD video to be compressed into DVDs. Similarly, HD MPEG-2 profiles are valuable for producing manageable HD video files, as compared to uncompressed video that require large storage options to manage files. The HDV type is an example of using MPEG-2 compression to fit the data stream onto SD data tapes (miniDV). The compression process discards data over the duration of a sequence, and between frames of an image (**inter**frame), as compared to within an image (**intra**frame) (Fig. 8). Interframe codecs such as MPEG-2 produce compact video files, but the "decompressed" clips may be difficult to view frame-by-frame and edit. More-recent computers and software can now edit "natively," without first requiring conversion into an intermediate frame-

based codec. However, some data loss takes place upon each recompression (export) of an edited file. Ideally, intraframe codecs, (e.g., DV, MJPEG, Cineform) would be preferable for editing and archiving, but given the popularity of MPEG-2–based recorders, they are likely to remain in wide use for fieldwork.

Recommended use: efficient capture and archiving; minimize editing.

Motion-JPEG

An older codec, M-JPEG compresses the images ("JPEGs" or JPG) of a sequence. Similar to DV, the video can then be viewed and edited as individual frames. While common as SD video in digital cameras, M-JPEG is sometimes offered as an option for HD capture, as an alternative to H.264 AVCHD or generic MPEG-4 video. The large file sizes (relative to H.264 files) are a disadvantage when storage is limited. However, this intraframe video codec is also easy to process on a computer. When storage space is not a constraint, M-JPEG represent a good option for archiving original video data. As an extension of the still image format, M-JPEG files may contain EXIF and other photo-style metadata such as shutter speed, aperture, and capture date. Unfortunately, this does not include GPS data. Currently, videos from GPS-enabled cameras only appear to record geospatial metadata to videos when using H.264 codecs in AVCHD or MOV formats.

Recommended use: archiving original clips and as an intermediate for editing.

Motion-JPEG 2000

More efficient than the legacy M-JPEG codec, M-JPEG2000 has the same editing advantages of using individual frames in a sequence. With options to hold onto image data losslessly and to include higher levels of colour information than 8-bit JPGs, it is a good codec for editing and archiving, especially for HD and higher resolution video. Although it is not encountered often as a capture codec (apart from digital cinema projects), this format may prove to be very useful for future applications in aquatic sciences when storing large digital video libraries.

Recommended use: archiving large collections of converted digital video.

MPEG-4

Modern and highly efficient codecs, this group has become popular for capture with solid-state (flash memory) recorders as well as for distribution on the web and on Blu-ray discs (Fig. 9). Many varieties of MPEG-4 files may be held in AVI, MP4, or MOV containers that can be transferred directly to a computer from its storage medium (with the exception of AVCHD, as discussed below). This is different from linear "stream" containers such as DV and HDV (MPEG-2), where the videotape has to be played and "captured" or "logged" onto a computer drive in real time before being available for editing. The major disadvantage of MPEG-4 is that scenes with much movement receive the greatest degradation from the compression, apparent as "blockiness" and the smearing of fine detail. Another constraint is that the playback and editing of (decompressed) files are very demanding, requiring the use of recent computers.

Similar to MPEG-2 codecs, temporal compression is used to discard data between groups of individual frames. While some systems can edit these codecs "natively," users may prefer to convert the original file to a "lossless" intermediate codec for editing, such as Cineform, Lagarith, and others seen in Avid and Final Cut Pro systems.

AVCHD is a special type of MPEG-4 H.264-encoded video that is recorded into a MPEG-2 stream as a folder of files instead of being packaged into the typical AVI, MOV, or MP4 container (see ovals in Fig. 9). While subsets of these AVCHD files are easily transferred onto a computer, the original metadata is often lost if they are not imported correctly into a video editor. It may be necessary to backup all data files prior to import, and to use special tools to read and export the hidden files (see Section 6.6). Video encoded and packaged as AVCHD are "natively" supported for viewing on HDTV and recording to Blu-ray disks (i.e., direct recording without format conversions).

Recommended use: efficient capture and data storage as originals or exports.
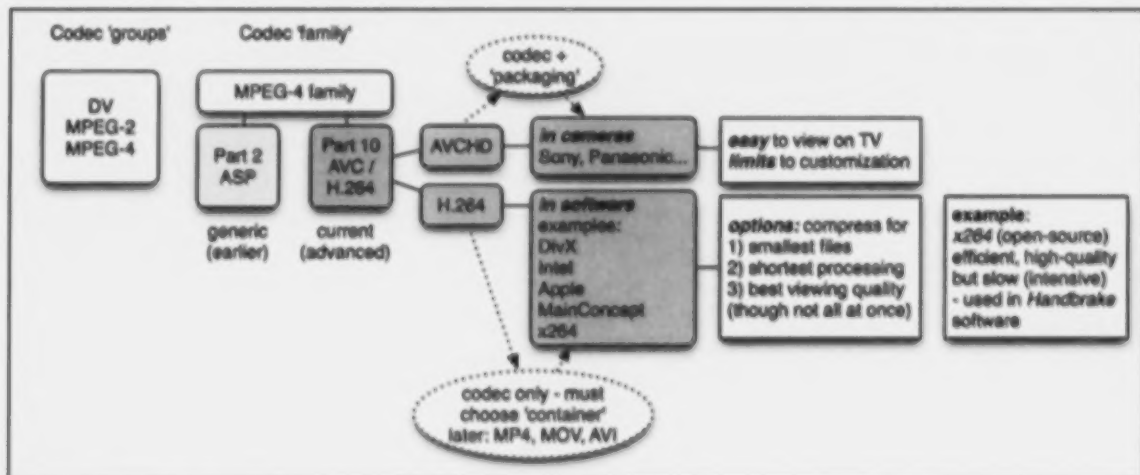
Figure 9. The MPEG-4 family of codecs is composed of several variants that differ in terms of availability, processing time, file size, or viewing quality.

Cineform

The difficulties in viewing frames and loss in quality when editing videos packaged into MPEG-2 streams (i.e., HDV, AVCHD) may make it worthwhile to perform edits in an intermediate, lossless codec. *Cineform* is an example for HD and higher video resolutions. However, the very large file sizes makes it prohibitive for consideration in long-term storage; files should be re-converted for distribution or storage. While converting files to *Cineform* is "visually lossless," metadata such as capture time and date are stripped and must be recovered from the original files. Visual data will also be lost when recompressing the file to a distribution format such as MPEG-2 or MPEG-4.

Note that the term **"lossless"** in video usually refers to **"visually** lossless" codecs that show no perceptible degradation when converting files from the original video, even though strictly speaking some data loss has taken place. Truly lossless video codecs, like RAW video, are rarely encountered, principally because of the prohibitively large file sizes they generate. Editing such files normally requires very expensive, ultra-fast, large-capacity storage systems such as fibre-channel RAID disk arrays, and thus are not discussed in this general guide.

Recommended use: intermediate for editing HD video.

Flash

Along with WMV, Flash is primarily a distribution codec for streaming video rather than one used for capturing or editing clips. Because of the popularity of the Flash plugin installed in web browsers, most Windows-based systems should be able to play Flash video embedded in websites such as YouTube. Future web development is seeking to reduce or eliminate the need for plugins like the Flash player, which may eventually see Flash being replaced with other codecs (i.e., H.264 and WebM).

Recommended use: streams in websites for computer-based viewing.

2.2.3. Digital video size standards

Along with compression codecs and media containers, digital video presents choices in video image sizes. Where once there was "standard definition" (SD) on televisions with DVDs (480 pixels high), there are now two common sizes of high definition video (720 and 1080 pixels high). Already on the horizon or in limited use are 2K and 4K video, and even higher-defined video such as Ultra HD (Table 4, Fig. 10).

As is currently done with digital photo cameras, eventually video image quality may be referred to by their pixel count. Instead of *"how many megapixels?"* a camera captures, queries for video may be *"how many K?"* in reference to the image width in pixels, as opposed to the image area in total pixels. For example, 2K video is 2048 pixels wide, with 2048×1080 pixels = 2.2 million pixels, or 2 MP in still images. Figure 10 compares the relative video image frame sizes, from standard DVD up to ultra high definition. For comparison, the black arrow indicates the relative size range with digital photos, from cell phones to 35 mm full-frame cameras (2 to 24 MP). Most video work in aquatic sciences is undertaken at DVD- or HD-level resolution. It is apparent that large increases in image data volumes might result from future standards, i.e., 2K, 4K, and beyond. It is recommended that video work in aquatic sciences employ the highest video standard (frame size and codec) possible, given the available capture and file storage equipment.

Table 4. Summary of digital video frame sizes.

Standard/name	Size (pixels)	Name	Use
NTSC DVD	720 x 480	Standard Definition video (legacy)	basic tools
HDTV 720	1280 x 720	High Definition video (current)	consumer tools
HDTV 1080	1920 x 1080	High Definition video (current)	consumer tools
Cinema 2K	2048 x 1080	Digital Cinema (replace film)	pro tools
Cinema 4K	4096 x 2540	Digital Cinema (replace film)	pro tools
Prosilica GE*	4872 x 3248	High resolution moving image camera	benthic towcam
RED Epic*	6000 x 4000	Very high resolution video	high-end cinema
Ultra HD	7680 x 4320	Ultra High Definition video	high-end cinema

* Prosilica and RED camera systems may take image sequences at various size resolutions.

Figure 10. Comparison of video frame sizes in pixels from DVD to Ultra HD.
Graphic based on elements in files:
http://en.wikipedia.org/wiki/File:28k_RED_CAMERA.png
http://en.wikipedia.org/wiki/File:UHDTV.svg.

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* Prosilica and RED camera systems may take image sequences at various size resolutions.
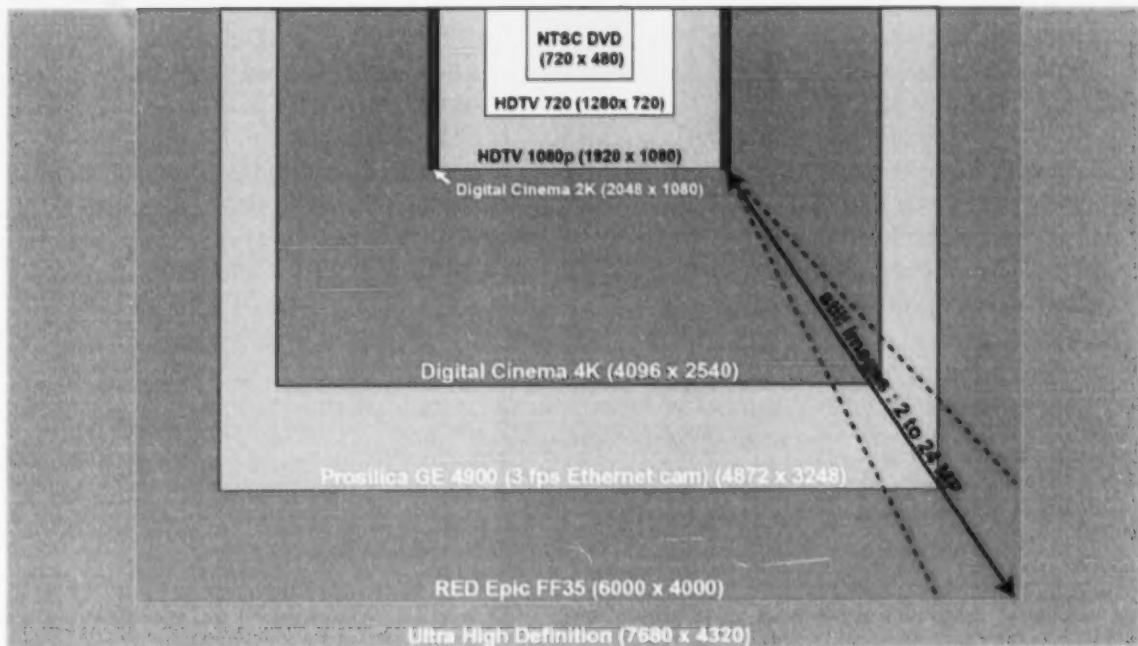
Figure 10. Comparison of video frame sizes in pixels from DVD to Ultra HD.
Graphic based on elements in files:
http://en.wikipedia.org/wiki/File:28k_RED_CAMERA.png
http://en.wikipedia.org/wiki/File:UHDTV.svg.

2.2.4. Digital video frame rate and field display

Historically, film and television have had standardized rates for displaying the sequence, expresssed as frames per second (fps). Television in North America (NTSC) is 29.97 fps and in Europe (PAL) is 25 fps. Film is usually 24 fps. In contrast, commercial camcorders are often reported as 30 and 60 fps (strictly speaking, 29.97 and 59.94, or 25 and 50 fps for European models). When preparing for broadcast television and film, the frame rates have important roles for video editors, especially when preparing for transfer to broadcast television and film. For computer use, the frame rate is not important so long as the hardware is capable of processing. However, an important property of broadcast is the requirement in the past for **interlaced** frames of video, where each frame is comprised of two fields: upper and lower. When displayed on a television, the alternation of half-fields is not noticeable to the human eye. For computer viewing, the combined half-fields may result in the onscreen appearance of lines, especially noticeable in action scenes. This "interlacing" and its removal for computer viewing or "deinterlacing" is becoming less of an issue as the trend is to make use of "full" or "progressive" frame captures, with no interlacing.

As interlaced video has half-frames, it may need to be combined into full frames for editing, thus requiring extra processing along with image degradation (softness). This may explain the preference by video editors for progressive captures. By comparison, consumers may prefer interlaced capture for its benefit of immediate, high-quality viewing on HDTV screens. Unfortunately, to meet consumer preferences, a number of digital camcorders are inherently "progressive" capture devices, but may only export processed video in an interlaced format for efficient storage (more minutes of recording) and direct viewing on DVD, HDTV, or Blu-ray.

As computers and video devices become powerful enough to capture and display progressive frames, the trend is away from interlaced or "i" frame capture. As a quick summary, video frames are commonly quoted in terms of "i" and "p" as follows:

VGA = 640 × 480 pixels, **progressive**: **30p**
- non-HD, or the "standard" video setting in cameras.

720p = 1280 × **720** pixels, **progressive**: **30p** or **60p** (high-speed video look)
- basic-level HD, good for high-speed action captures

1080i = 1920 × **1080** pixels **interlaced** (usually **60i** that *began* as 30p)
- full-size HD in mainstream cameras

1080p = 1920 × **1080** pixels, **progressive** (**30p,** or slower 24p for "cinema" look)
- full-size HD in better camera models (no interlaced output)

Note that manufacturers may restrict the range of capture settings on consumer video camera models. Indeed, a great deal of debate and ratings of consumer camcorders are

based on the available options for frame rates (progressive and speeds) and bit rate (compression and levels of colour data).

On some "prosumer" cameras, it may be possible to output live from a camera data port (FireWire, HDMI, or Ethernet) to a computer "capture deck" that has the processing power to receive and process the video signal without packaging into the camera's internal format like MPEG-2 or AVCHD interlaced streams. This allows for the retention of the original full frames, and usually with more color data, in an advanced codec that is easier to edit but requires much more storage space for larger files. However, it also requires tethering to an external capture device while filming. This type of video capture is routinely used with cabled (tethered) underwater vehicles (AUV or ROV; see example in section 5.7), but otherwise may be uncommonly encountered in aquatic sciences.

2.3. Image annotations: metadata tagging

Along with the image, there is the structured information used to describe the characteristics of the image object, often referred to as the "metadata" or data about the data (Fig. 11). Information held as metadata can take on a variety of forms and is found in direct association with images (*object level*) or as part of related information among other data sets (*group level*). Science projects are accustomed to working with large amounts of data and have begun to leverage the utility of metadata when managing datasets in aquatic biology and chemistry, such as the Marine Metadata Interoperability Project (MMI) and DFO's BioChem and OBIS-Canada. In the photojournalist community, the value of annotating images was realized during the transition from film to digital images. Image tagging was standardized by the International Press Telecommunications Council (IPTC) to help photographers find and distribute their work files (International Press Telecommunications Council 2010).

At present, the standards for metadata in still images are well-developed and in wide use, far beyond their origins in photojournalism. Several aspects of object level image metadata are technically important only for photographers, such as details about capture and permissions (e.g., copyright, employer, model release). For science, other kinds of metadata are of interest, by adding value to image files, by informing on file origins, subject, and quality or usability. It should be noted that video metadata standards are much less developed than those for still photos. Therefore, this section of the guide will focus on the annotation of digital still images.
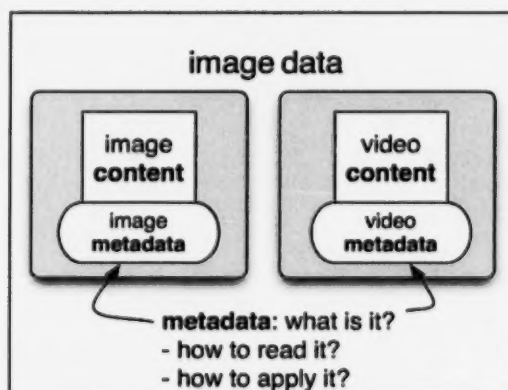
Figure 11. An image file has visual content and metadata.

2.3.1. Metadata classes

Image metadata may be generalized as information regarding an image as an object or as part of a group. The *object level* is most commonly associated with work on individual image files while *group level* annotation involves managing collections of images, often in association with environmental data in science projects.

2.3.1.1. Object level metadata

Annotation of image files is an activity commonly encountered at the *object level*. Any data editing that occurs at this stage may be embedded into the image file so that the metadata is retained when the file is moved. The "future-proofing" of files provided by embedded metadata reduces the reliance on proprietary cataloguing software that holds metadata at the *group level* (as will be shown in the next subsection).

Currently, photo metadata has expanded into overlapping areas of standards for basic technical data (camera EXIF), photojournalist codes (IPTC fields), and extensible data fields (XMP). These standards cover three types of object-level metadata: 1) file (computer), 2) capture (camera), and 3) user data. Working with image metadata usually refers to the latter two categories, namely capture (EXIF) and user data (IPTC-XMP), while file data is associated with common computer operations. The three types of object-level metadata are listed in Table 5 and their features are summarized below.

Table 5. Summary of object-level metadata types for still images.

Metadata	Standard	Comments
File	ASCII, Unicode (text)	Avoid symbols and punctuation for future compatibility
Capture	EXIF (technical)	Not for editing, except to add GPS or correct date/time
User	IPTC, XMP	**Easily edited**; shares (duplicates) fields with other types

File metadata
File metadata has a number of uses:
- file properties (format, creation date, size) can be searched (Fig. 12)
- file name (and folder name) may hold a brief summary of information; useful in case embedded metadata is lost or for files are moved from a folder (Fig. 13)
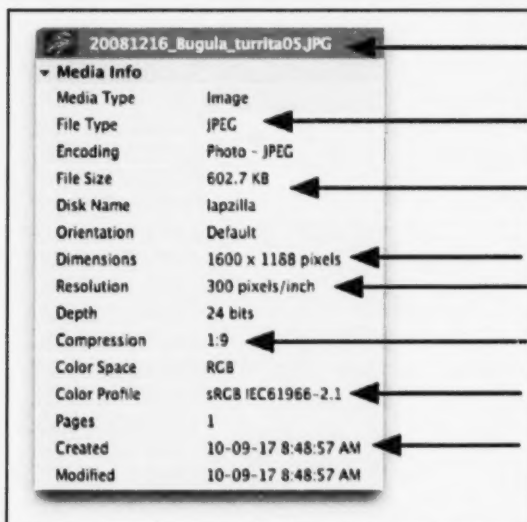
Figure 12. Example of file metadata. Several property fields (arrows) can be useful for data searches and directly viewed with a file browser such as *Windows Explorer, Google Picasa,* or *Apple Spotlight,* or with a digital asset manager (cataloging software)—in this case, *Microsoft Expression Media.*
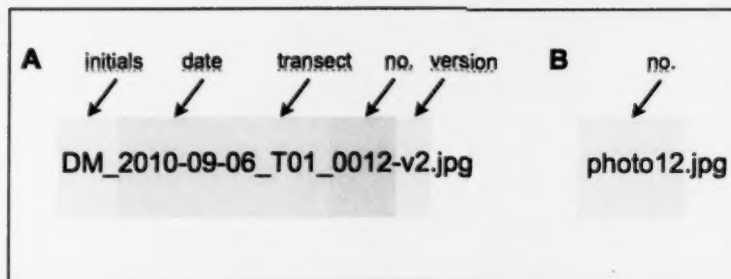
Figure 13. File naming for metadata purposes. (A) File name with multiple instances of stored information. (B) Generic file name with minimal information.

File naming is an easy way to provide information on a file, but it is also risky. In some instances, such as storing on networks or burning to optical disks, very long names, special characters (accents), and punctuation can be misread or become truncated. In these cases, the information is lost. As several characters are reserved for special file operations, it is recommended to only use the underscore or hyphen characters for punctuation (Fig. 13 A). Previously, files under MS-DOS were limited to "8.3" for filename.extension, but long filenames up to 255 characters are available on Windows and Mac OS X. Note that a "feature" of older Photoshop (Windows and Mac) when exporting JPG in "Save for Web" was to limit names to 30 characters unless the user **un**checked the option for "Mac OS 9 compatibility" (legacy format). In the past, this "bug" may have resulted in confusion about file name limits.

Capture metadata

These fields are automatically captured by your camera. They are designated for technical information during the image acquisition by a camera:

- capture date as original file date (not always the same as "file creation date")
- other fields of interest include aperture, shutter and ISO speed
- optionally may contain GPS and copyright information

While it was once difficult to access, most software is now able to read these EXIF fields, although fewer packages allow access to writing data (see Section 6). This is deliberate, since fields are written at the moment of image capture and are meant to be read-only, except for the need to do corrections, such as the camera date and time.

Images from video cameras, and some flatbed scanners, generally do not contain EXIF data. Video clips from some still camera models are an exception. In most cases, some form of capture data may still be available. Some video formats record a **timecode**, or numbering of a frame in the sequence, which may be as important as the **date stamp** (capture date and time). For example, annotating an underwater video involves documenting items viewed according to a video frame number (where in a clip the observation took place), but also the time/date of capture (often associated with mission

and position). Similar to EXIF fields in still images, the reading of capture data in video files may be performed in advanced software or require the use of special utilities, namely *DVMP Pro*. For example, in Fig. 14, the metadata from the original clip was read and "burned in" to the frames of an exported clip using *DVMP Pro* (see Section 6.6).
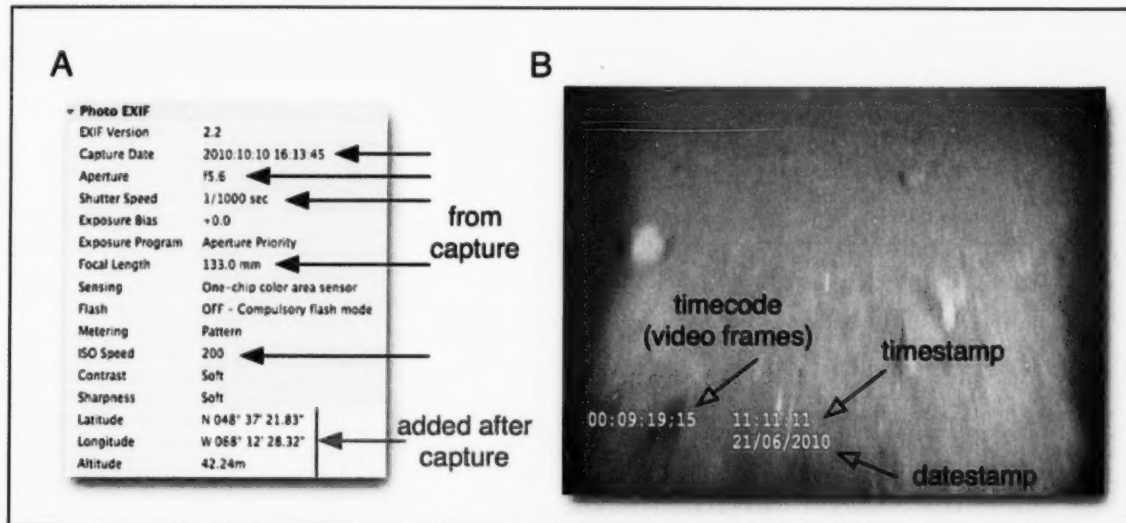
Figure 14. Examples of capture metadata. A) Recorded as camera image properties in EXIF. B) Recorded as a video frame overlay: timecode, time and date stamp.

User data (IPTC, XMP: rating, label, keywords, place, creator, copyright)
The user data fields are the most commonly filled when tagging images:
- easy to edit and contain many fields (provision for custom fields)
- not all fields are always available (depends on software)
- many fields have little value for aquatic sciences (intended for photojournalists)
- these can be co-opted for use in science, with reservations

For still images, user-added metadata, or annotations, are used to describe, identify, and inform about an image file. These annotations may be minimal (contact name and a keyword) or highly detailed, including custom fields. These data may be embedded into the image files so that the object-level metadata may be read in different software programs. For video files, tagging clips with user data information is less well-known; when available, it is usually only applied and read at the group level.

User supplied metadata are categorized under several groupings of information. Initially, global tags are grouped to provide information on origins (Fig. 15, red labels). These include the IPTC fields of creator and copyright as well as location and title. Because this information usually applies to all images in a series, they may be applied at the moment of file ingestion, often as part of the preset metadata (see workflows for example). Once files are ingested and tagged with this preset metadata, the next

grouping would be to include the information that pertains to quality. These are the *ratings* fields (often as 1 to 5 stars) and colour *labels* (to indicate a stage or usage). In addition, some programs include *flags* (rejected, flagged, or unflagged). All of these types of markers make it easier for the user to sort through large numbers of files (Fig. 15, blue labels).

Another group of user data is the subject-related details: *keywords, captions,* and other descriptive information (Fig. 15, green labels). Keywords are some of the most valuable of the user-added tags, but their application can be daunting because of their flexibility. They require the use of a controlled vocabulary (Appendix 2) and style guidelines when sharing catalogs or exporting to collections.

Finally, because these annotations are readily editable, their "intended use" may be co-opted to meet specific needs for projects, which will be useful only if well-documented (see Section 5.7 for case examples). For simpler projects, it is best to use the minimal fields in their intended fashion.

Figure 15. User-level annotations for an image in an *Expression Media* catalog.
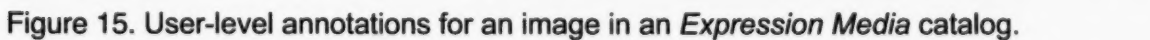
In Fig. 15, the example image—selected on the basis of a keyword—displays a number of editable fields to add information on file origin, mark its value, or give more detail on the subject. Coloured arrows indicate different groups of user data: black (standard metadata), red (also standard, but used here for custom purposes), blue (quality markers), green (subject; open to several terms and uses).

2.3.1.2. Group level metadata

Two features are often associated with *group level* metadata. First, the information is found outside the image file (object). Second, the image file is presented virtually—i.e., as a preview—in reference to the source file, which is stored elsewhere. There are major advantages to keeping data stored apart, particularly with speed as databases grow in size, in order to manage many thousands of linked files.

For aquatic sciences, "group" metadata will have special meaning when referring to the pooling of data into projects, which often includes information regarding images (Fig. 16). Depending on the project, this amalgamation may take place at different—but occasionally overlapping—levels that may refer to collections, image banks, cruises (missions), or science data portals and schemas (Table 6).

Table 6. Examples of group level metadata types.

- **Collection** data (image catalogs: physical and virtual groups or sets; see Sec. 6.4 and Appendix 1)

- **Image banks** (SERPENT, LIFE, CaRMS/WoRMS, Morphbank, ImageGeo and others; see Sec. 7.2 and Appendix 3)

- **Mission data** (associated data from cruises, such as geospatial, molecular, taxonomic; see ROV example in Sec. 5.7)

- **Scientific metadata schemas** (e.g., jMetawriter, DublinCore, DarwinCore, GCMD; see Sec. 6.7 and Appendix 2).

Apart from an awareness of the differing levels, it is important to highlight the importance of sharing data across levels, between "groups," and also with "object-level" data fields. A major focus of metadata initiatives in defining standards is to assist in a two-way exchange of data, or "crosswalking" data tables. The aim is to ensure that the work done at one level, in some area, is carried forth without excessive effort into other data pools. Further information on leveraging data across groups by using controlled vocabularies is listed in Appendix 2.
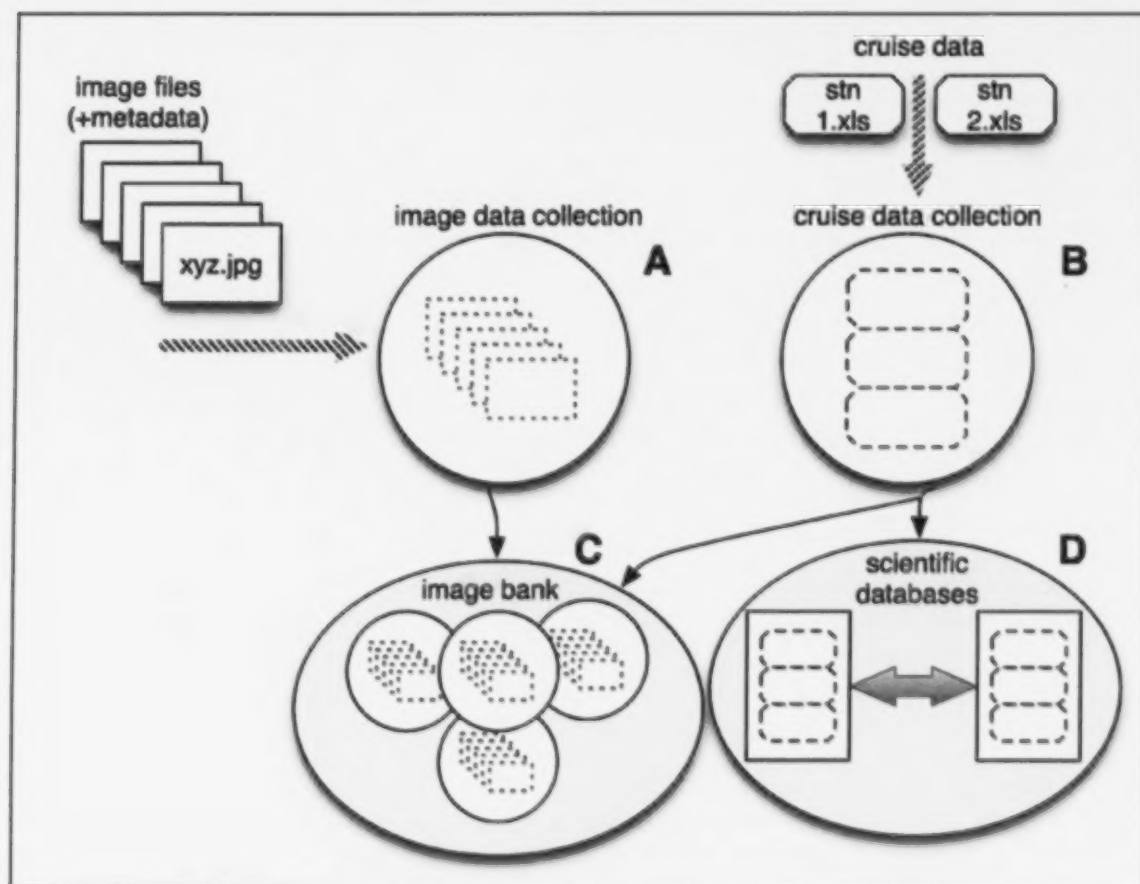
Figure 16. Examples of group-level metadata: (A) image metadata sent to collections; (B) cruise-related metadata sent to collections; (C) collections compiled into an image bank; (D) collections read into metadata schemas for use in databases.

2.3.2. Image geotagging: a special case of metadata

Geotagging refers to the annotation of GPS information stored in the technical data fields (EXIF) of a JPG or RAW image file. A number of fields are available, but those of greatest interest are latitude, longitude, and altitude. Because only a few digital cameras are able to geotag at the time of image capture, this geospatial information is frequently added afterwards. Special tools or software plugins are used to do this basic operation because *capture data* is not intended for editing (Fig. 14).

Manual geotagging of an image is done when GPS or capture data is unavailable. If the image was taken from a well-known location (i.e., a landmark), then the coordinates of that location may be written to the file. (Fig. 17 A)

When the location is known but the coordinates are not available, a digital map (e.g., Google Earth) can be used to point to the capture site on a digital map and save the coordinates to the image file. Working backwards in this manner is referred to as *reverse geocoding* (Fig. 17 B).

Standard geotagging occurs when an image is synchronized to coordinates based on the clock time of the camera and the GPS. In this scenario, an external GPS records a continuous track while the camera is in operation. Software is then used with the GPS tracklog and the time of capture to geotag the image file (Fig. 17 C).
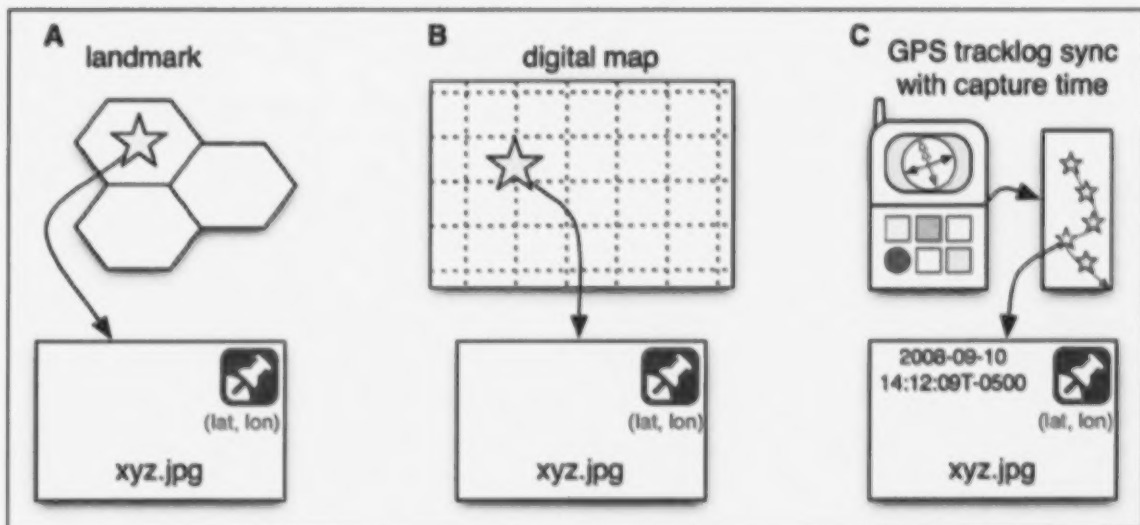
Figure 17. Principal methods of geotagging images post-capture: (A) referring to location from a known landmark, (B) locating the site on a digital map, (C) recording a tracklog to synchronize with the images based on date and time.

Apart from manual and standard geotagging, several cameras have embedded (or tethered) GPS units that will write the EXIF time, latitude, longitude, heading, altitude— even the city and location (IPTC fields). An unintended benefit of embedded GPS in cameras is the reliability of timestamps in images because they are now automatically set by information from the GPS satellites. There is no need to manually check and correct the camera's clock; this is a common source of error, especially when travelling between time zones. However, an internal or tethered GPS may record tags with gaps or errors in GPS fix, especially upon startup or when shooting indoors, although these may not be obvious from the camera display of coordinates (Table 7). Several GPS-enabled compact cameras contain an internal database of world place names and tourist sites, with the camera display showing the tagged image on a map.

Table 7. Benefits and drawbacks of embedded GPS for geotagging images.

Feature	Internal or tethered GPS	Manual or external tagging
Speed	Slow – must wait for GPS fix or images will have no (or bad) data	Instant – if turned on in advance (but must remember to do so)
Accuracy	Good, but success of tag is not always easy to confirm	Good, if camera time for sync is correct, or map coordinates known
Timestamp (EXIF)	Automatic sync to GPS satellites (no need to set clock)	Requires vigilance to maintain the camera clock synchronized and correct time zone if not using UTC
Other data (IPTC-XMP)	Auto-fill fields for city, etc., based on nearest position	Control over choosing data to put into fields such as location, city
Battery life	Operation drains smaller cameras (not a problem for DSLRs)	Better battery life for camera

2.3.3. Video geotagging

While several still cameras now have internal GPS, video geotagging is less well-known, with only a few models that record track to videoclips, and even fewer software programs able read this data (see sections on *DVMP Pro* and *CatDV Pro* in the software workflows). Nonetheless, several consumer cameras are now producing geotagged files (Fig. 18), and location metadata is popular in social networking. As with other consumer image technologies, this interest may lead to the increased availability of spatial video tools, including for work applications. The latest examples may be seen in "point-of-view" experiments posted on science blogs in 2010 using aerial devices (balloons and gliders) to carry cameras that record video with GPS tracks while deployed over land and water.

Currently, only selected AVCHD camcorders from Sony and Panasonic with internal GPS modules can record spatial tracks to the video clips. When filming video clips with these still cameras in AVCHD format, the video file will also contain a track log. As with most metadata in AVCHD files, the track log can be difficult to read and to preserve.

One of the best ways to preserve AVCHD metadata, including the GPS tracklog, is by using the DVMP Pro software (see DVMP workflow in Section 6.6).

Another area of popular video geotagging is with smartphones such as the iPhone, which records spatial information in MPEG-4 video clips using the MOV container format. The spatial information in this container can be read by most software on Apple computers, including *QuickTime X*, *iPhoto*, and *Aperture*. On Windows computers, the cataloguing programs of *CD Winder* and *CatDV Pro* can also correctly read this information from the QuickTime MOV container (see Section 6.8 *CatDV Pro* workflow for examples). Although the MOV container format is capable of handling spatial information, careful consideration should be given to your choice of video editing tools, as most video editing software will strip off this information during processing.

A	B	C
camcorder (.mts)	helmetcam (.mov)	smartphone (.mov)
extract GPS track from AVCHD files	*edit and extract GPS tracks with QuickTime tools*	
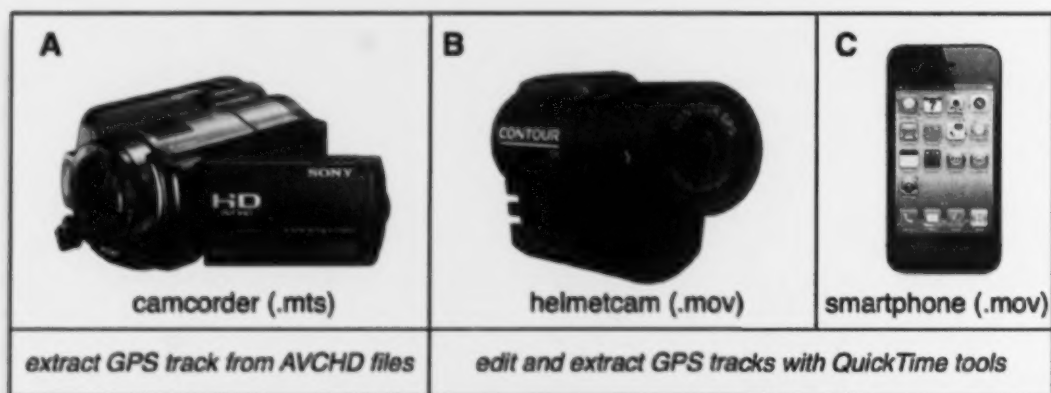
Figure 18. GPS-enabled H.264 MPEG-4 video cameras: (A) selected AVCHD camcorders, (B) point-of-view camcorders, and (C) smartphones.

Overall, spatial tagging in video file containers is currently poorly known and difficult to view, edit, and manage. The capacity for GPS tags in AVCHD-type files and MOV containers suggests that there is a potential to do more at the object (clip) level. However, it does not appear as if the other popular video containers (namely AVI, MP4, and WMV) have any provisions for spatial metadata. In these cases, geotagging video will have to continue to rely on the traditional methods with collections:

- using analog spatial data viewed on-screen (visual burn-in, e.g., Fig. 14 B)
- managing digital spatial data in external databases, i.e., group-level metadata management.

2.4. Image editing

The editing of image data is often associated with corrections or enhancements of photos for cosmetic or commercial purposes. Many of the features in editing software may be superfluous to aquatic science work; however, a number of the functions in consumer software are valued for making the best use of captured images.

2.4.1. Image editing software systems

Since the appearance of image software such as Photoshop twenty years ago, editing was performed similar to database operations, namely, by proceeding in steps, keeping track of changes, and saving copies of the image file at different states. These types of edit changes are sometimes referred to as "destructive": unless saved as very large files with multiple layers and history states in a Photoshop document, the user cannot return to the original image state (Fig. 19 A). When correcting for lighting or other edits, improved software may appear in the future that will be able one to perform optimal processing, but until then, it is often prudent to retain the original image files. However, keeping copies of originals and various edits may quickly become unwieldy to manage and require a vast amount of storage space.

In recent years, "non-destructive" photo-editing and management software (Fig. 19 C) has enabled a workaround for the classic problem of multiple copies and huge storage demands. For example, in newer versions of Photoshop, editing with RAW files and "smart" layer objects in Photoshop documents is non-destructive, that is, the state can be reverted to the original with no degradation with each save.

For most users, this advanced level of non-destructive editing has not been as significant as other approaches taken with software at the consumer level. To assist beginners in managing images, software such as *Google, Picasa,* and *Apple iPhoto* use a default and hidden versioning system, with any edit automatically resulting in the creation of a new file that is then shown, or discarded if reverting to the original. The risk of accidental deletion of originals is eliminated, and therefore editing is non-destructive. While simple, this default behaviour is invaluable for saving trouble, especially with mixed workgroups where it may be challenging to keep track of originals and edits of image data (Fig. 19 B).

In 2007, several editing programs appeared that took the approach of non-destructive editing even further. As in the case with the class of hybrid "ILM" cameras (i.e., non-SLR, interchangeable lens, electronic viewfinder cameras; see section 3), this new category of software is difficult to label in a word, although some (Krogh 2009) have proposed calling it **Parametric Image Editing**, or PIE-ware. PIE-ware editing software does not alter the original image files, but instead records the edits as a set of instructions (Fig. 19 D). Currently, the most popular PIE-ware is *Adobe Lightroom 3* (Windows and Mac). Others include *Apple Aperture 3* (Mac only), and *Phase One Capture One 6*, oriented for studio and medium-format photographers (see Section 6).

What unites parametric image editors is the concept of managing photo files (standard formats only: JPG, RAW, TIF, PSD) by displaying previews of the source. All edits take place by following the processing instructions and displaying it as a preview. These instructions are "parametric edits," so new copies of files do not need to be saved with each edit, only the small set of text-based instructions. The instructions are retained in a catalog or may be written back to special metadata fields in the photo file (i.e., XMP) so that the processing may be re-interpreted in another image editor or viewer.
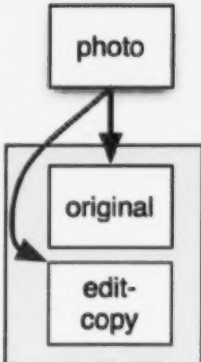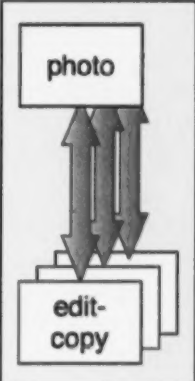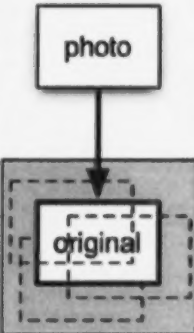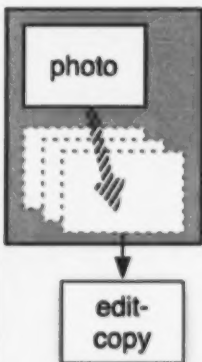
	A	B	C	D
editing type	Manual: copy, or else destructive	Auto-protect edits as copies	'Smart Layers'	'Parametric' editing
editing work	photo → original → edit-copy	photo ↕ edit-copy	photo → original	photo → edit-copy
featured behaviour	must **remember** to save edits as **copies** along with originals	any edits saved as **new** copies (original is untouched)	edits in **layers**: copies not *required* (but files are large)	edits are instructions to original; exports as version on demand
software example	Photoshop	Picasa	Photoshop CS (recent versions)	Lightrooom

Figure 19. Comparing image editing systems and their use of file copies.

The typical approach in image editing software is to manually modify a file and save as a separate copy (A). This may be supplanted by "non-destructive" systems, where edits are *automatically* saved as copies (new versions) (B). Special layers in a Photoshop Document (smart objects in a PSD file) may also be called non-destructive by saving edit changes as a history while preserving the original pixels (C). More advanced still is the "parametric-editing" system (D), where original photos are not modified: edits are processing instructions, displayed with live previews, without modifying the original pixels. Actual copies of edited files are only generated on-demand in parametric editors.

While PIE-ware packages such as *Lightroom* are conceived as efficient photo editor/manager systems, there are some constraints. Work is done on individual files, but these may be exported as actual copies for more advanced processing in a graphics editor like *Photoshop* or with external plug-ins.

2.4.2. Special edits: multiple image composites

In the preceding discussion, image editing has referred to the process of modifying a single photo file. A single file may also be modified to become part of composite file. A simple composition has added elements such as text or symbols in the image. Multiple image composites are special edits that may have particular value in aquatic sciences.

2.4.2.1. Panorama and mosaic composite images

In "photostitching," a series of overlapping images may be merged together to form a large composite image. A panorama is made by pivoting the camera to shoot a wider scene. With mosaics, the camera or the subject is moved in successive shots, for example, to cover a large map or a specimen. In both cases, shots from a low-resolution camera result in a high-resolution composite (Fig. 20).
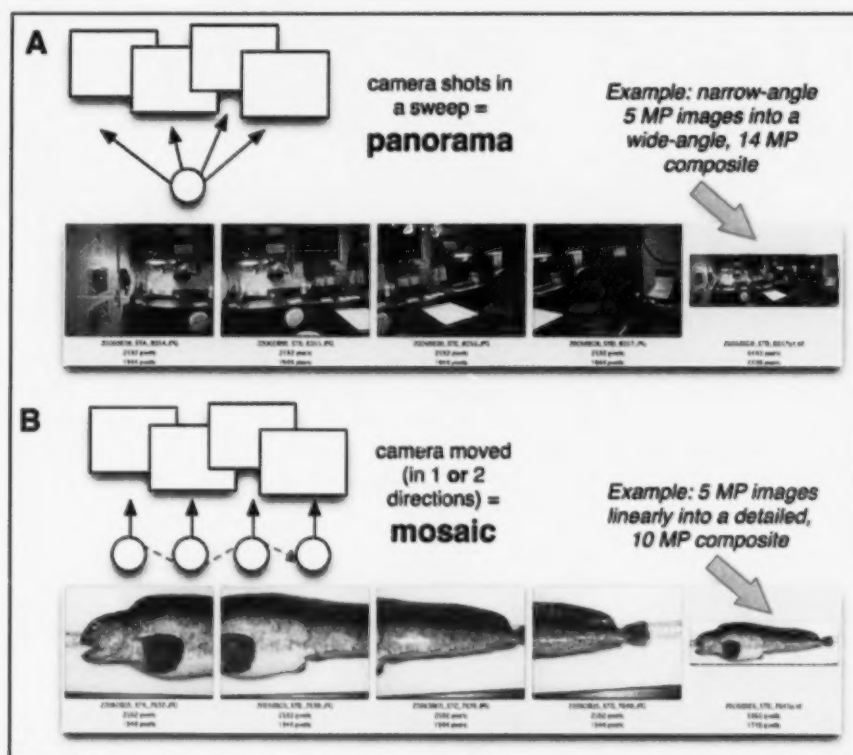
Figure 20. Image composites produced as (A) panorama or (B) mosaic.

2.4.2.2. HDR images

Groups of images, or stacks, are also used in two other kinds of image merging: dynamic range and depth of field. Creating an image file with high dynamic range (HDR) involves merging several different exposures to capture details in very bright and very dark areas of a scene (Fig. 21). Because of the narrow range of the electronic sensor, the file with combined over- and under-exposed shots may be more similar to what the human eye sees. HDR images are a photographic creative tool, sometimes used to exaggerate the effect. For science work, HDR is an important technique when photographing in very bright environments, in order to capture both bright and shadow details, especially if only JPG format is available (RAW images have more range).
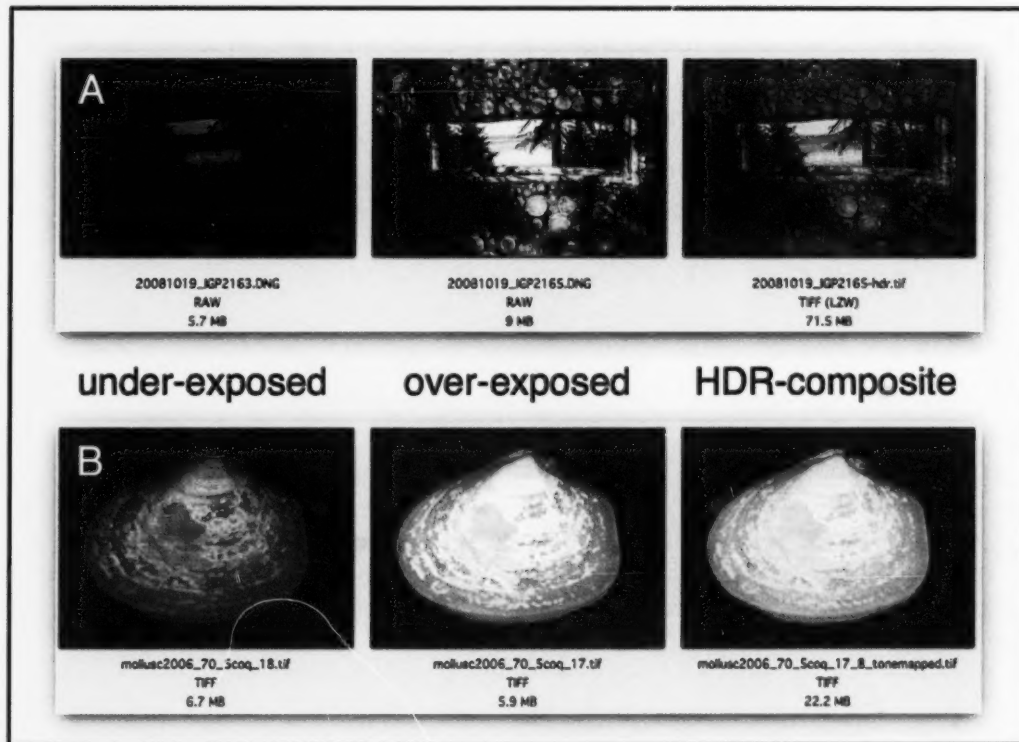
Figure 21. Images merged to retain highlights as a HDR composite: (A) white geese in a sun and shade scene, (B) bivalve shell in a microscope camera.

2.4.2.3. Focus stacks (depth of field)

A final class of merged images involves depth of field or "focus stacks." In macro photography, the plane of focus can be very shallow. This may be used for creative effect, but in documenting specimens for science, an image with all details in focus is preferred. To achieve a greater depth of field, a smaller aperture is used on the camera, normally from f/8 to f/22 on DSLR. A high number like f/16 or f/22 will give more depth

than a smaller number. However, the **high** numbers refer to very **small** apertures (opening of lens iris) so that a very bright light, a tripod, or a high ISO setting may be necessary to achieve an image without blurring from motion with slow shutter speeds. Even with bright lighting, images become degraded when using high aperture numbers, due to optical diffraction. Therefore, the highest-quality detail occurs when combining several images, each taken at a different point of focus and at the optimal aperture of the lens. Typically, this is f/8 on a DSLR, or f/4 on a compact camera. An example is found in the software workflow for Helicon Focus (Section 6.9).

2.4.2.4. Purpose of composite images

As shown in the above examples, a composite image is created from merging several image files to produce a new file. The small previews in the examples do not show the full extent of the advantage of composites, which is to say the gain in image tones and subject detail. In some instances, the higher level of tonality and detail can be obtained by using more expensive, high-end cameras and lenses with the ability to capture greater dynamic range and more megapixels. Merged composites allow for lower-end consumer equipment to produce similarly detailed files. Thus, a 1 or 3 MP camera such as on a microscope or a smartphone can produce large mosaics, and with better range of tones, when combining several shots.

2.4.3. Video editing

Video editing presents special challenges to protect against destructive data loss. Virtually all video is compressed with some degree of data loss, depending on the codec used. With HD video, algorithms to compress and discard data are tailored to produce small files while minimizing loss as seen by the human eye. Compact files, unfortunately, are not always convenient for editing, and further data loss may occur on editing and saving (recompressing) a video clip. To lessen the degradation during editing, a visually lossless, very high quality codec may be used as an intermediate format. After editing, the file can be recompressed using various codecs, depending on the intended use, i.e., for archive (best quality, full size), for standard display, or for web delivery (highly compressed, small resolution).

While the use of "lossless" intermediate codecs will lessen the degradation of video , there as yet no common* equivalent to the parametric editing of raw files as seen with still images. Video metadata is less well-known and the embedded information in a clip is often lost when editing, including the metadata fields of date, time, and GPS track. The use of intermediate codecs almost always strips away original metadata. For this reason, if video image data and metadata are important for distribution, original clips must be preserved, along with the clip versions. Hopefully, future development in video standards such as CinemaDNG will lead to metadata-aware management similar to that with still images and DNG (see Section 2.2.1 on image formats, Table 1).
(*some high-end niche products may offer 'raw' video, such as RED).

2.4.3.1. Video editing work

- Compared to still image workflows, video files are more constrained in the actions and options available to editing and managing content
- In part, this is because there are many types of codecs and format containers for video that will affect the visual quality of the file
- Several codecs and formats are better for certain work stages, such as capture, editing, or archiving
- Metadata is generally poorly managed in video editors
- Only a few video catalogers exist, and most rely on preferred codecs and formats to read and edit metadata
- Video work is often non-linear, with different work undertaken by returning to the "source" files to perform metadata tagging, video quality editing, or distributing different formats (Fig. 22)
- Video editing often eliminates original metadata such as the timecode (original sequence of a videotape or file), especially for HD video (i.e., HDV, AVCHD), requiring special tools to retain or repurpose the information, as in visual burn-ins (see example in Section 6.6 DVMP Pro)
- Until a few years ago, video capture was predominantly based on magnetic tapes
- Capture media is currently diverse, with optical discs (DVD), hard drives, and flash (solid-state chips on cards) available in consumer camcorders—all of which are readily accessible media for transfer and editing on computers, as compared to the situation with video tapes

In the work example shown in Fig. 22, A) the capture and logging of original files from tape to computer is relatively straightforward, needing minimal processing such as file renaming and wrapping of the file in a standard format container. B) Subsequently, several choices are available for the captured clips to be cataloged, modified (metadata burn-in), enhanced, edited, or compressed for delivery.
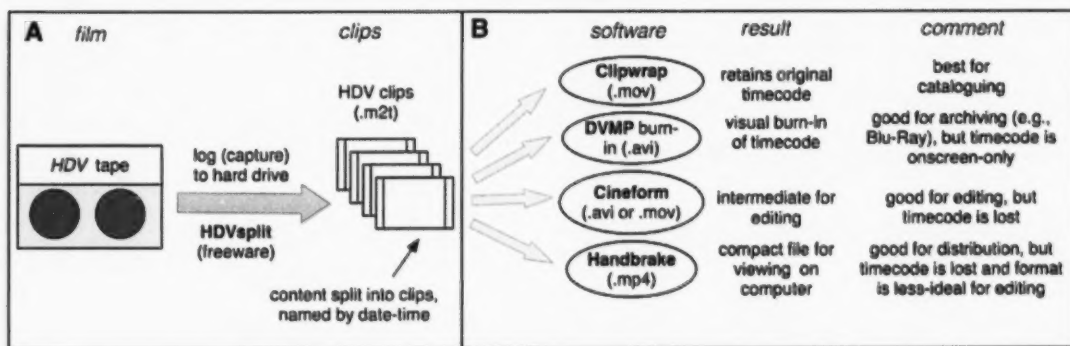
Figure 22. Example of multiple video editing pathways with HDV files.

3. EQUIPMENT

3.1. Cameras and their development

Today's electronic devices are presented with a bewildering range of models and technical jargon, making it difficult sometimes to gauge a device's utility and potential uses. Obtaining good image data is largely a matter of technique when acquiring, editing, and storing files. However, familiarity with equipment types and their practical limits will increase the chances of success, particularly when used with the workflows presented in Section 4.

A number of trends with cameras are responsible for the present-day state of digital imagery. In the past decade, emulsion-based photography (film) has effectively been replaced with digital captures, and cinema is looking to follow suit. The legacy of film cameras is seen today most importantly in physical structures, i.e., camera bodies and lenses. The arrival of digital video brought electronic sensors and media files that are managed using software. The advanced processing requirements of handling video files have resulted in a raised awareness of the relationship between image quality and the development of hardware and software. While traditional 35 mm, medium, and large (8 × 10 in) format cameras produce very high quality images, the results from smaller digital devices are often more than sufficient for many situations in science work, and it may be easier to manage and edit their files. On the video front, the capacity to produce images in a sequence in a variety of formats has expanded the traditional view of "video camcorders," with virtually all still cameras able to serve as hybrid "camcorders." While low-end cameras produce video clips inferior in visual and audio quality to the output of a dedicated camcorder, they are however widely available (low-cost) and their files are generally easier to manage, edit, and distribute. Because of their large image sensors and quality lenses, video-capable DSLRs may rival video camcorders in image quality, but the camera bodies are designed for taking individual shots and thus filming can be awkward, especially in their focus and audio controls.

As listed in the surveys of cameras in the following section, developments and "cross-overs" with imaging devices are underway (Fig. 23). Judging by the camera metadata submitted to online photo sites (e.g. Flickr), phone-cameras are increasingly popular, or even the dominant sources of image data. It will be interesting to see what new hybrid imaging products will emerge in the future and how they will be adapted for use in aquatic sciences.
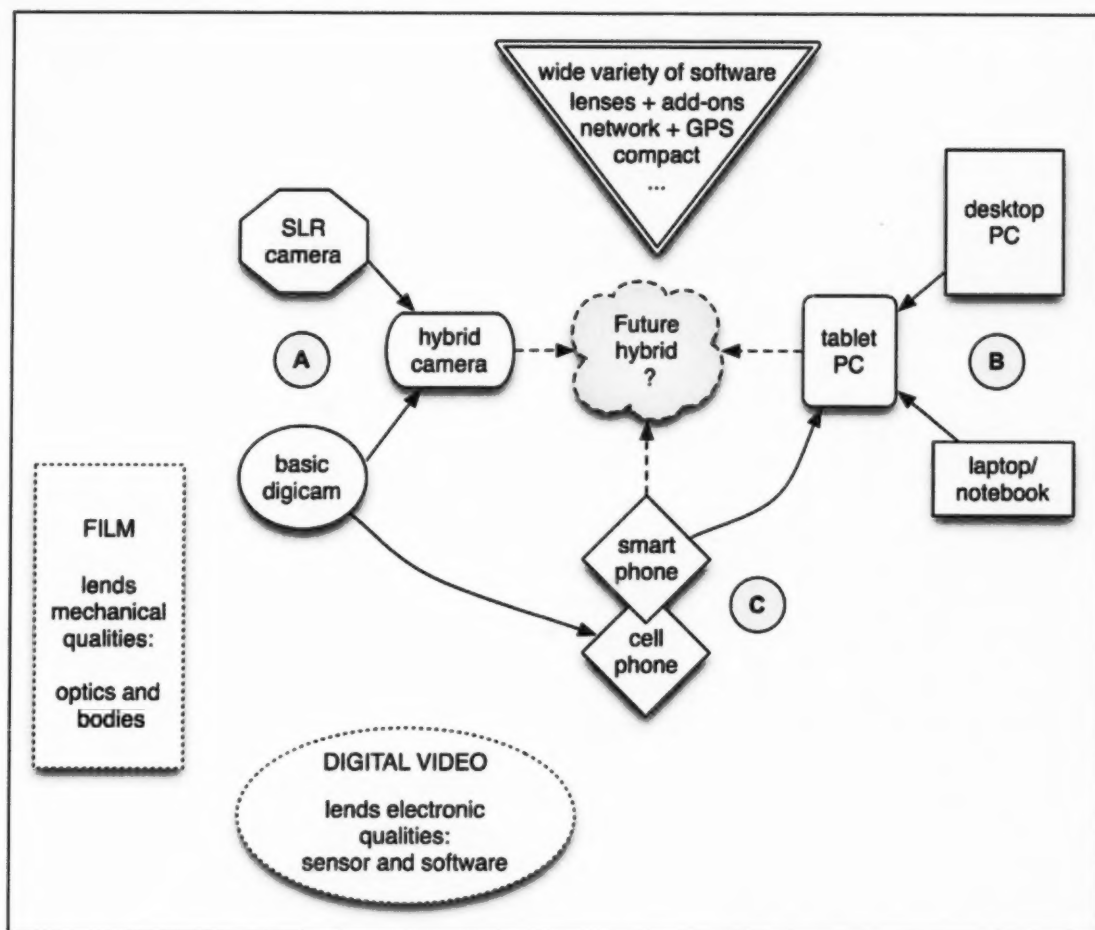
Figure 23. Ongoing convergences in consumer imaging devices for A) digital cameras, B) personal computers, and C) cellular (mobile) telephones.

3.2. Cameras: digital photo

Current digital still cameras are equipped with high-resolution sensors (5 MP or more), sufficient for making letter-size prints and viewing details on a screen. Distinctions among camera types are on the basis of cost, construction quality, body size, capture rate, and sensor quality, with compromises being made in one or more of these features. While image quality should be paramount, the choice of camera often depends on availability—whatever is at hand when an item is to be photographed. It is thus important to be familiar with the limitations between camera types and the possible alternatives, which will lead to better choices in collecting image data.

At present, most discussions and comparisons between camera types and image quality examine the quality of the sensor for light gathering and data processing. A major factor in light gathering is the size of individual pixels. Sensors with a large surface area usually have larger pixels with better sensitivity (lowlight ability), less digital noise, and greater tonal range. Smaller imaging chips hold denser arrays of pixels (Fig. 24). However, along with putting more pixels on chips, manufacturers have been resourceful with data processing to overcome the limitations of the smaller pixels. Consequently, megapixel count and sensor-size remain useful measures for comparisons, but are not the only means to assess the capability of a digital camera.
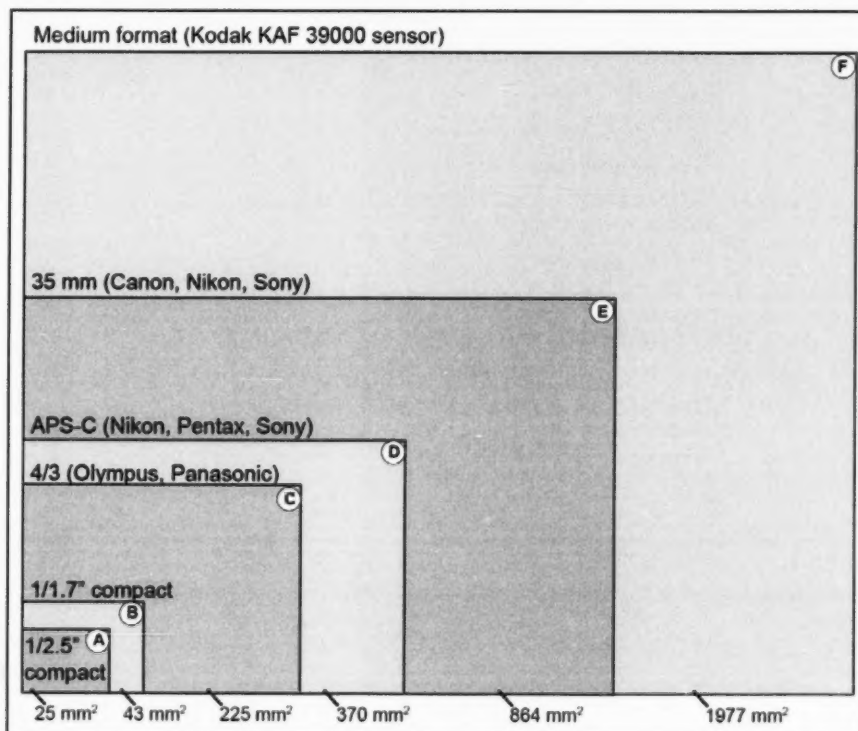
Figure 24. Size comparison of still image sensors: compact digicams (A, B), Four-Thirds systems (C), cropped APS-C (D), full frame 35 mm (E), medium format (F). Derived from: http://en.wikipedia.org/wiki/File:SensorSizes.svg

Basic compacts
- inexpensive and small form factor (no viewfinder; use screen to compose)
- work within limits (small zoom range, poor in lowlight, slow shot speeds, jpg files)
- may be very good in bright, outdoor light (ISO 50-200)
- often good with macro (<10 cm focus, large depth of field in focus)
- can produce video clips (image and sound quality varies among models)

Recommended use: document outdoor field operations.

Advanced compacts
- add features for higher quality (zoom range, manual controls, raw files)
- still have tiny sensors – poor results with low-light work (ISO 800-6400)
- very slow shot-to-shot speed (1 to 3 frames per second)
- very good with macro (0-10 cm focus, large depth of field)
- some may accept filters and accessory lenses (wide-angle, macro, etc.)
- video clips may have good image quality (autofocus)

Recommended use: projects with good lighting such as macro/microscopy or outdoors.

DSLR (digital single-lens reflex)
- traditional-looking (35 mm) cameras (bulky, heavy, and expensive)
- large sensors for better low-light work (ISO 800-6400)
- wide variety of available optical lenses and accessories
- high frame rate (can take several shots per second)
- optical viewfinders with live view (screen) in most cases
- currently do video, with caveats (e.g., focus, exposure, rolling shutter issues)

Recommended use: aerial and underwater surveys.

ILM (interchangeable lens mirrorless)
- new family of cameras – similar quality as DSLRs, but with less bulk and cost
- electronic viewfinders and better at video than DSLRs (autofocus)
- larger sensors give better results at ISO 400+ compared to compacts
- still new: small range of accessories and lenses

Recommended use: alternative to compacts and DSLRs.

Smartphones (cellular phones with built-in cameras and on-screen software)
- very basic image quality (less than dedicated cameras)
- software available to edit and send photos and video files without a computer
- some may be good at macro (including barcode reading and label OCR)
- embedded geotagging of photos and videos (rare feature among cameras)

Recommended use: simple images for easy reference (e.g., images of labels, features, barcodes, satellite timestamp, and GPS data for tagging photos from other cameras).

Tethered/network camera
- basic network or web cameras for surveillance (inexpensive, low-light sensitive)
- industrial and scientific imaging devices (expensive cameras, high-speed cables)
- transmit using FireWire, Ethernet (copper or fibre-optics), USB, or wireless (wi-fi)
- potential to take high-quality still photographs (current models capable of 16 MP TIF, several times a second), sent via cable to computer on-board ship

Recommended use: fixed site monitoring or time-lapse, and major underwater surveys with live view and high image quality.

Medium format (6 × 7 cm, 6 × 4.5 cm frame)
- expensive (10-60K$) cameras or sensor plates ("backs") for existing cameras
- specialty products of Hasselblad, Mamiya, Phase One, and Pentax
- larger sensor than 35 mm DSLR results in higher level of detail

Recommended use: aerial photography such as marine mammal surveys.

3.3. Cameras: digital video

The field of consumer digital video has expanded in the past decade, going far beyond the standard-size frames and formats popular with television and DVDs (See Section 2.2, Fig. 10). In their stead are a variety of HD devices using newer consumer file formats with more efficient compression schemes. At the same time, there has been an increase in quality and availability of video from digital still cameras, turning them into "hybrid" video cameras. At the low end, most important is the ready-at-hand **availability** of miniature recorders, although most only perform well outdoors and may be poor in lowlight situations such as the interior of wet labs. At the higher end (beyond HD), cameras take a series of images from 2 to 16 MP that may be processed as a video sequence or analyzed in detail, for example, as a static mosaic of continuous images while proceeding along a transect. A summary of camera types follows below.

Basic consumer video cams
- traditional handstrap camcorders
- tape drives; now superseded by optical discs, hard drives, and flash memory
- common formats: miniDV, HDV, DVD, AVCHD
- source of video footage for many surveys (i.e., underwater videos) in the past

Recommended use: basic project filming.

Advanced consumer video cams
- "prosumer" camcorders: bulky, with interchangeable lens, audio inputs
- offer higher-quality (higher bit rates) versions of file formats
- used mostly in video documentary projects by TV production houses

Recommended use: high-quality footage or marine expeditions and projects.

Compact (photo) camera
- video clips from a photo camera
- easy autofocus and lighting (usually few or no controls)
- basic to very good quality in image, audio, and metadata
- common formats: MJPEG and H.264 MPEG-4 contained as AVI, MOV, MP4 files
- AVCHD is less common (GPS-equipped models geotag videos; see Fig. 18)

Recommended use: clips to complement photos, or as a quick substitute for a video camera, to demonstrate operations in the field or use in a presentation.

HDSLR camera (video-capable DSLR)
- recent feature of DSLRs; most current models now capture video
- common formats: MJPEG and H.264 MPEG-4 contained as AVI or MP4 files
- higher quality (lowlight noise, colour) clips when compared with smaller cameras
- choice of lens and controls allow for a "cinematic look" (shallow depth of field)
- some issues (rolling shutter, manual focus) compared to other cameras

Recommended use: currently by experienced users, but may become widespread.

ILM camera (interchangeable lens mirrorless)
- new family of camera type; intended for photo, but very good at video
- electronic viewfinders and good autofocus for video
- larger sensor means potential for less image noise than smaller cameras

Recommended use: alternative tool for documenting operations and surveys.

Flip-style video cams
- inexpensive, flash-memory video recording devices, handheld vertically
- quick and easy to operate (few controls) and to transfer files to computer
- common format is H.264 MPEG-4 contained as AVI or MP4 files
- video quality is usually low-to-acceptably good SD or HD

Recommended use: not suitable for most work, but may receive files from public contributions, e.g., animal strandings and other events.

Smartphones
- compact, easy-to-use, and most-likely to be available for spontaneous videos
- usually the lowest-quality video (smallest image sensor), but depends on models
- georeferenced video (i.e., iPhone embeds location data in MOV format)

Recommended use: tagged files (embedded time and location data) to reference with other video cameras, or as a basic video recorder when no other is readily available.

Network/Tether cam
- stream for live capture recording on a computer or storage drive
- site monitoring with "security camera"-like systems for long-period, autonomous recording of animals swimming in tanks (see Sect. 5.5)
- elaborate systems used in underwater tethering to a remotely operated submersible (see Section 5.7)

- some handheld camcorders can be tethered to send direct video streams to a capture deck, potentially bypassing the need for HDV or AVCHD compression
- consumer webcameras are usually low quality, but widely available on laptops and as a USB camera for PCs, and thus may be useful for non-demanding situations, such as filming a procedure in a lab for a presentation
- network surveillance cameras (Ethernet or Wi-Fi) may use IR illumination (without IR filters on camera and with IR LED lights) for low-light work, i.e., night environment during experiments (see Section 5.5)

Recommended use: tethered remote filming (underwater vehicle or laboratory work).

2K/4K/RED cam
- next generation of "high definition" (greater than 1920 × 1080 pixels) video
- some may offer "raw" video instead of being compressed and wrapped in consumer codec formats such as DV, HDV, AVCHD

Recommended use: currently limited availability, but these tools offer the best quality for future projects where image detail (e.g., benthos on seafloor) and colour discrimination (e.g., seals on ice floes) are important for photos and video.

3.4. Imaging Accessories

The ease with which image data are obtained and their quality may be improved through the use of add-on tools and accessories. While these may be well-known to photographers, in science, workers may be less familiar with these tools. The following are some examples of accessories of benefit for image work.

3.4.1. Supports

Tripods (full-size and compacts) – holds the camera horizontally
- for slow speed (lowlight), long-exposure, time-lapse work
- also useful for site monitoring (repeated shots) and panorama/panning

Copy stands – holds the camera vertically
- for close-up macro work: multiple shots at different points of focus
- allows consistent work: same height, lighting, backgrounds

Soft supports – improvised for handheld shots
- beanbag other soft item such as jacket or hat to absorb vibration/hand shake
- alternatively, lean and steady camera using a body part (elbow, knee)
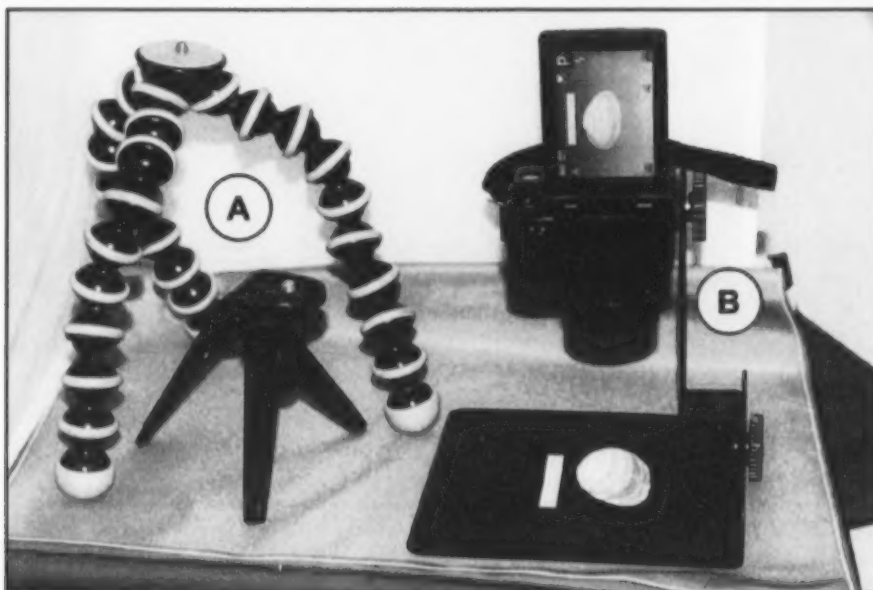
Figure 25. Examples of compact camera supports. (A) Pair of inexpensive tripods. (B) Mini copy stand. Note also the use here of a portable "softbox" (fabric panels velcroed in a cube frame) to diffuse the light and provide a uniform background.

3.4.2. Lighting

Flashes – attached or remotely triggered
- assist as fill-in or shadow-free light for macro lab photography
- underwater photography – dives and tows

Continuous lights (fluorescent, halogen, LED)
- daylight fluorescents or halogen for laboratory photos and underwater video
- high-power LEDs for underwater video with efficient battery packs (vs. halogen).
- low-power LEDs such as ring lights for fill-in light or to assist with camera autofocus

Daylight fluorescent lamp

Macro ring flash

Underwater high-power LED lamp

Macro ring light

Figure 26. Examples of light sources for field and lab work. Many now use LEDs for energy-efficiency (portability with battery packs) and lower heat output.

3.4.3. Reference markers

White balance
- target for correcting colour due to lighting (indoor, outdoor, underwater)
- critical image work is done using a standard colour chart (Fig. 27 A)
- may be improvised (i.e., find a white object in field of view of an image)

Scale bar
- ruler or other item of known length in field of view
- may be improvised using a printed label or a common object in view
- video work often uses parallel lasers points (separated by a known distance)
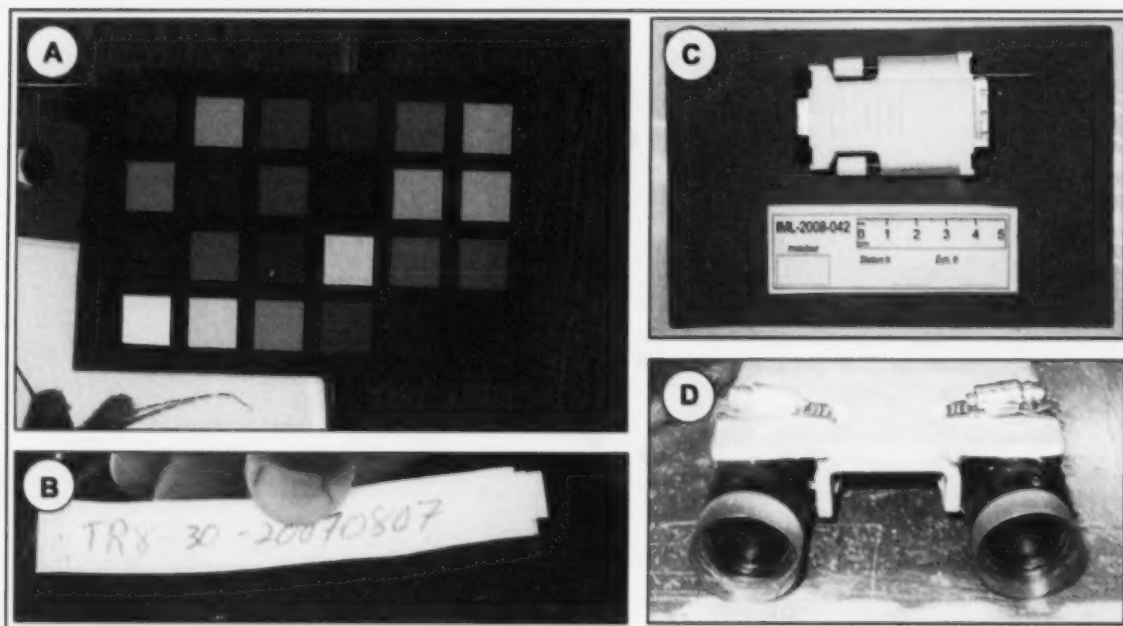
Figure 27. Reference markers. (A) Colour card. (B) Image of a sample label to be placed into specimen bag. (C) Printed label with scale bar and a contrasting background. (D) Twin lasers spaced at 10 cm, providing a fixed scale when projected at various distances while filming underwater.

3.4.4. Filters and other lens add-ons

Neutral density filter
- to reduce incoming light in very bright conditions, e.g., snow or icefield

Polarizer filter
- to reduce surface glare at air–water interface, as when viewing fish
- to remove atmospheric haze, enhance colour saturation

Macro closeup lenses

- add-on lens clipped or screwed onto main lens to boost macro capabilities
- usually only available with advanced cameras (adapter for model)
- generally provides about 1x to 5x magnification
- offers better images than when using normal macro, i.e., at 1 cm distance; camera lens is further out – less barrel distortion than at close wide-angle

Figure 28. Example of a magnifying add-on lens: Raynox DCR-250 being used on (A) an advanced compact camera with set of Lensmate adapters; (B) a DSLR camera with a 43–49 mm filter adapter ring; (C) a basic compact camera with adapters, (D) here seen assembled for use.

Microscope adapters

- simple adapters to hold camera in front of the eyepiece (results may vary)
- special kits with optics to be used in microscope tube (expensive – $100s)
- dedicated microscope imaging systems (very expensive, $100s and more)
  - not an accessory but shown here for comparison (Fig. 29 C, D)
- compacts give good results and are easy to use when an adapter is available
- DSLRs use a T-mount; potential for better images, but cumbersome
- generally used for 10x – 80x magnification of detailed aquatic organisms.
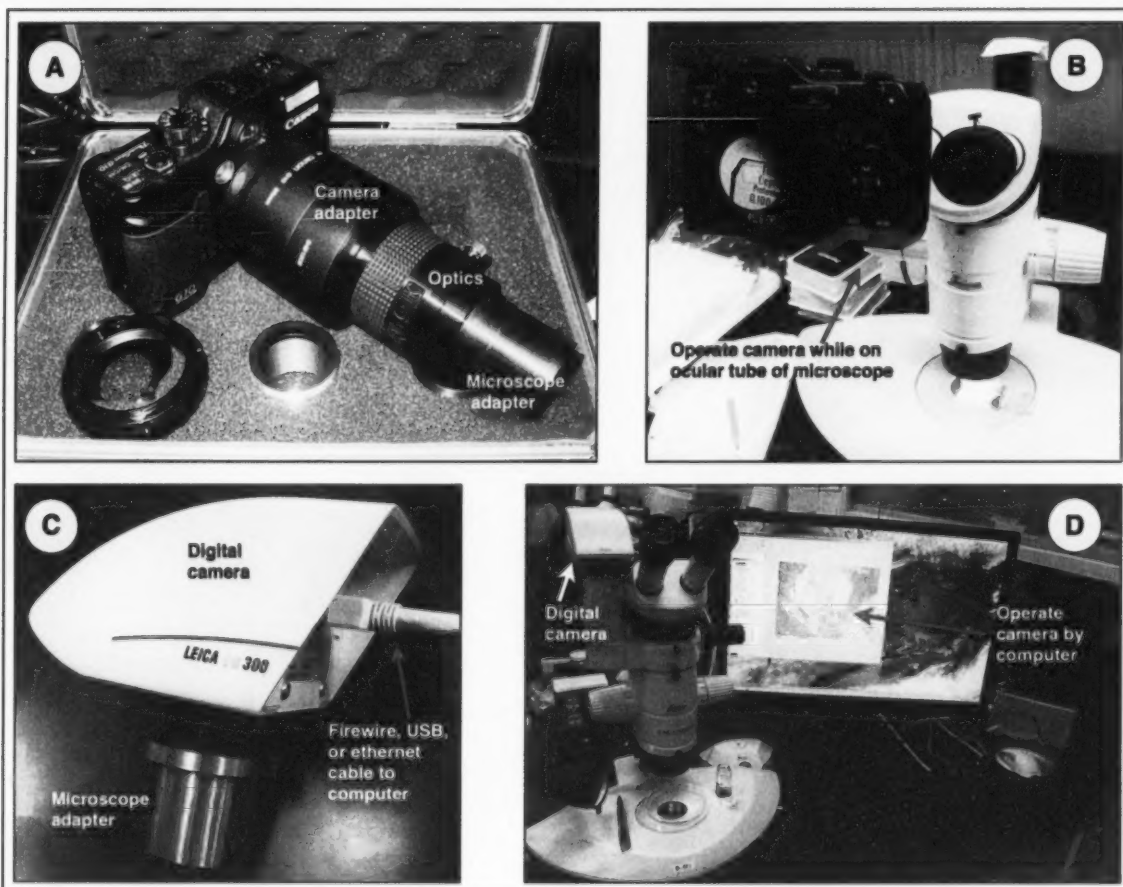
Figure 29. Examples of microscope imaging. (A) Advanced compact camera with eyepiece adapter kit, and (B) as seen on a binocular dissecting microscope. (C) Microscope camera from a dedicated imaging system, and (D) as seen mounted on the microscope and operated via computer.

3.4.5. Other camera accessories

Cases
- waterproof bags and boxes to transport cameras in open boats
- hard waterproof cases to operate cameras underwater
- soft waterproof bags for casual use while on the water or in wet labs
- note: several cameras are now offered in waterproof models
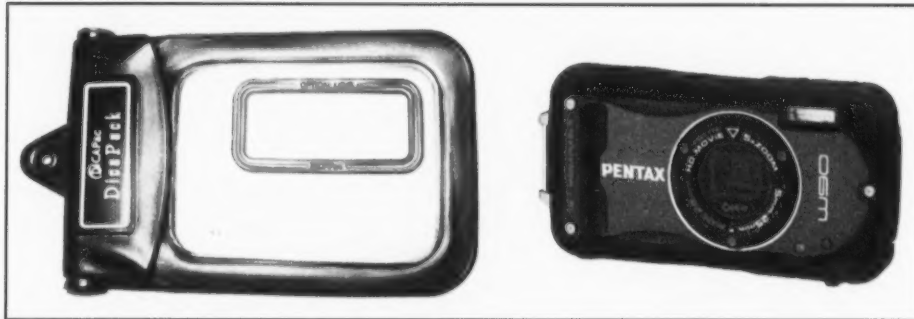
Figure 30. Basic underwater imaging solutions. A waterproof soft pouch for a regular camera or smartphone (left) and a waterproof camera (right).
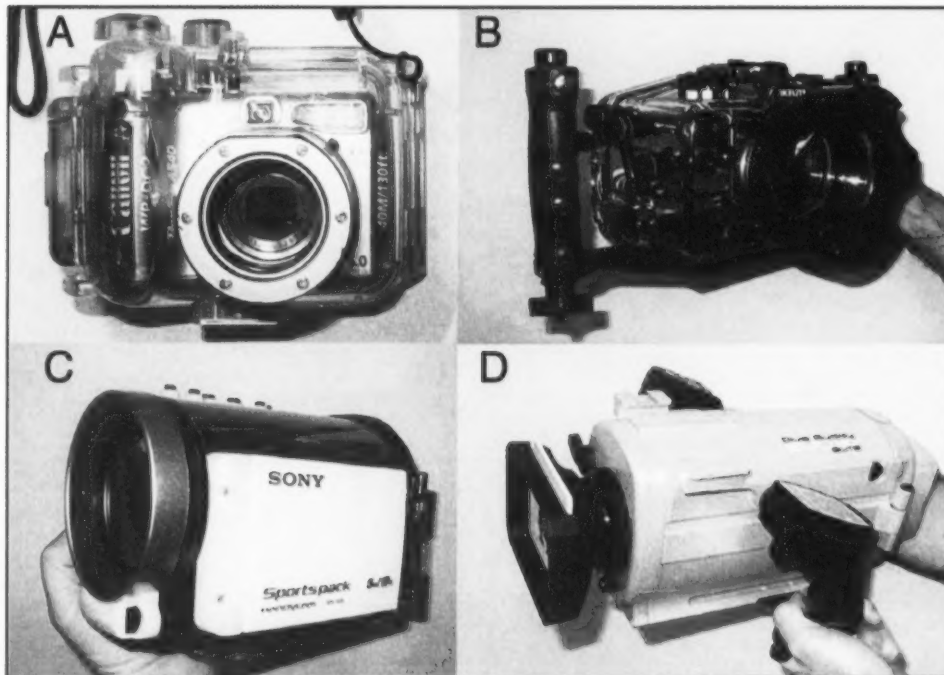
Figure 31. Underwater camera housings: (A) compact camera case; (B) DSLR housing; (C) compact camcorder case; (D) full-size camcorder case.

Portable GPS
- camera-tethered units embed data directly into images (mostly for Nikon DSLRs)
- handheld units with screens, e.g., Garmin, create tracks for reference
- data loggers (automated tracking, no screen) create tracks for reference
- smartphones obtain positions with GPS or cell towers &/ WiFi signals; can export tracks to tag images or make geotagged images for later reference with others
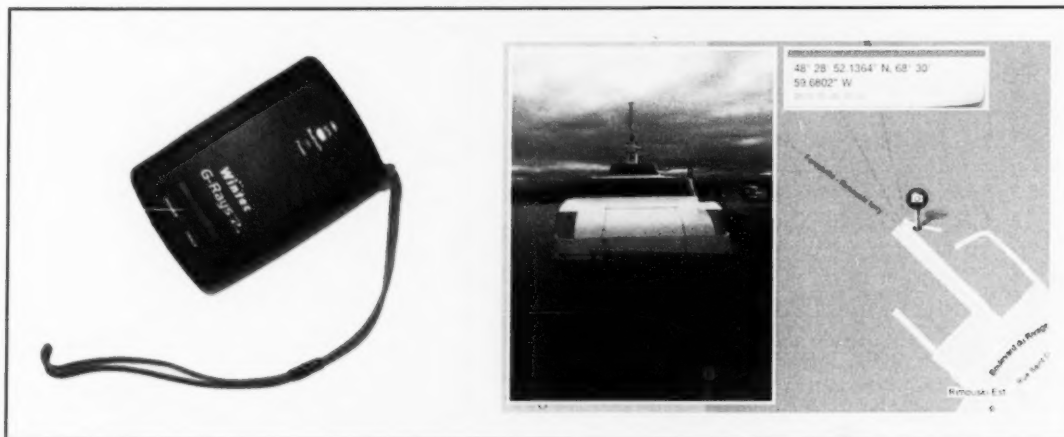
Figure 32. Geologging tools. Left, a bluetooth GPS data logger for recording tracks Right, a smartphone app exporting an image as a mapcard (a photo on map).

Wireless transmitters (Wi-Fi, Bluetooth)
- add-ons for high-end DSLR camera bodies (Canon, Nikon)
- integrated into some models of compact cameras
- memory cards (Eye-Fi) for Wi-Fi transfers with most cameras
- new category arising: transfers between smartphones and tablets or PCs

Transmitters serve to send files to online galleries or to view progress immediately on an external screen monitor, for example, to confirm focus during macro photography.

Nikon DSLR wireless (Wi-Fi) transmitter | Ricoh industrial camera (waterproof, Wi-Fi, Bluetooth, GPS, laser barcode scanner) | Eye-FI Pro SD memory card (JPG, RAW, video file transfer and geotagging by Wi-Fi)

Figure 33. Examples of wireless image transfer tools.

Video encoders

- camera throughput, using a DV or HDV camera as an analog–digital converter to capture via FireWire (IEEE 1394a or iLink), USB2, and HDMI cables
- simple add-ons for analogue ports relayed via USB2 and using software for processing on a computer (Fig. 34)
- hardware-based external decks, internal PC cards, or USB-based dongles for better quality and faster processing compared to software-only encoding

Consumer devices are often software-based, giving average quality results or slow processing. Faster processing is possible when using dedicated external hardware (Fig. 34; black device at right).
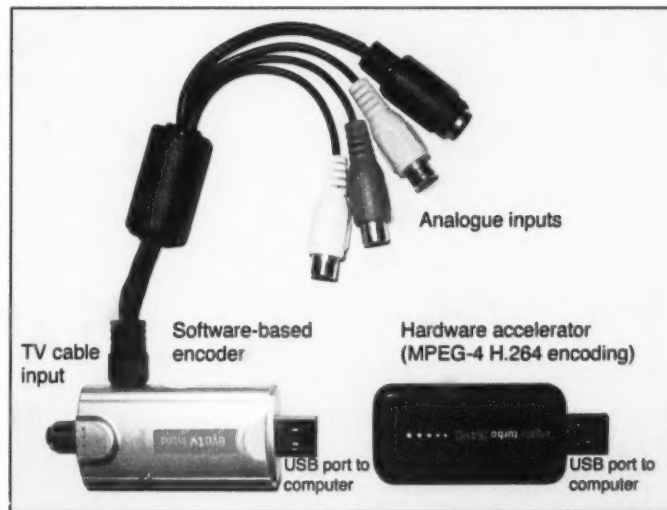
Figure 34. Inexpensive USB video encoders.

3.5. Computer Operating Systems

Science operations within DFO work principally with Windows-based systems (Windows XP), but image data is also managed and received using other systems, especially from academic and commercial partners. Users may be called upon to recognize differences when sending or receiving files between operating systems. In general, issues between systems are minor for still images but may become critical with video because the different systems have default preferences for "their" formats (Fig. 35). Thus, for video media, additional software and plugins are often necessary to read or convert files into the preferred editing formats (shown in bold in Fig. 35) of other systems. Mobile devices have additional constraints, requiring optimized codecs to run on their lightweight processors.
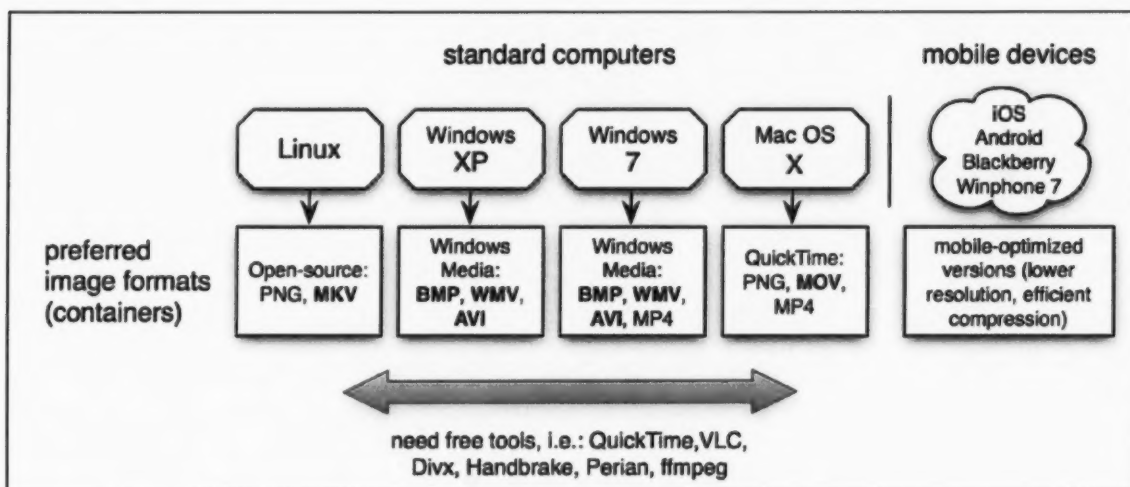
Figure 35. Computer operating systems and their preferred or default media formats.

Windows XP: Base system installed for most PC workstations in science projects, including DFO. Work with current files often requires installation of extras e.g., image and video codecs, plugins, and players such as QuickTime, Flash, Java, and VLC.

Windows 7: Future base system to be installed on PC workstations. Includes more recent image and video codecs, although several still need to be installed along with media packages, such as QuickTime 7 and VLC. The possibility of using more than 4 GB RAM memory and 64-bit processing enables handling of very large image files and videos, as may be encountered with geospatial imagery and high-definition video.

Mac OS X: Video work in OS X relies on QuickTime-based systems and containers, i.e., MOV, rather than the general AVI containers seen in Windows systems. Editing video is generally preferred with AVI for Windows, but advanced management and metadata for video (e.g., GPS coordinates) may use QuickTime-based systems on both

OS X and Windows. On OS X, viewing and editing Windows Media video files (.wmv) requires installation of additional codecs and plugins for QuickTime. Other tools may be also be used for AVI files (e.g., Handbrake or VLC).

Linux: Basic free tools and advanced (HD) packages for processing image and video data are available on Linux. Scientists may also be familiar with Linux-based tools, especially in oceanography and network computing, and in web projects. Installation and troubleshooting may be challenging to non-technical personnel. Commercial software may represent a challenge if unavailable on Linux, especially for reading and writing metadata held in proprietary systems, e.g., Adobe's XMP, Apple's QuickTime, Microsoft's Windows Media.

Mobile OS (smartphones and tablets such as Android devices, Blackberry, iPhone, iPad, and Windows Phone 7): Abundance of simple software available for free or at low cost (relative to desktop commercial software). The flexibility of software tools is quickly becoming apparent in macro, micro, and regular photo and video capture. Lightweight, customized tools can also be developed easily and quickly for related data and resources such as tide tables, buoy data, marine traffic, taxonomy lists, nature guides, and vessel and animal observations. Already popular with consumers and artists, advanced mobile OS developments are still new for general work and are likely to appear first for organizations before institutions. Some recent examples in 2010–2011 include:

- **Neptune Canada** (marine data portal, including images and videos)
- **PLoS** (app for open access marine and aquatic science articles in PLoS journals)
- **LeafSnap** by Columbia/UMaryland/Smithsonian (automated photo-ID of plants)
- **Taxonomy** by Aaron Thompson (querying ITIS taxonomic names database, with links to species images)
- **Phyto** by NOAA (phytoplankton identification images)
- **Project Noah** (post images of species occurrences on various user-led missions)

3.6. Computer Hardware

With the comparatively low cost of modern computers, obtaining hardware for most image users is not a major concern; photographers and videographers will equip themselves as needed to perform the planned tasks. However, in public science, staff must use what is available at the workplace. It is important to verify if this equipment is adequate and what may be upgraded during the planning of a project. Some points to consider:

- older computers (5+ years) are too slow for HD video editing
- portability (laptops) versus expandability (desktops with extra ports, drives)
- cost of replacement versus upgrades: processors, graphics cards, and memory
- use of multiple, large monitors is more efficient for image analysis (e.g., counting)

Typical computer specifications (memory, processors, graphics) are constantly being updated; computer and camera data ports change less often, thus these are discussed here.

3.6.1. Summary of data ports

Many computers found in laboratories and offices have only the basic ports, such as USB2, Ethernet (network), and video (VGA or DVI). This is sufficient for average use on standard photos and videoclips, but advanced projects will work better with higher-speed ports for the importing, viewing, and archiving of high numbers of large image and video files. Preferred ports are summarized in Table 8.

Table 8. Recommended ports for computers, drives, and cameras.

Data port	Usage
USB2	common, inexpensive; good for regular data transfers (MB, GB) in the field
FW800	when using multiple desktop devices concurrently in a chain
eSATA	faster than FireWire and USB2, but tricky to attach/disconnect (need to reboot)
USB3	for rapid transfer of GBs or TBs of data (if this new port is available)
Ethernet	transfers over a local area (longer cables than USB, faster than Wi-Fi)
Thunderbolt	hybrid computer and video data port by Intel; will become optical in the future

While add-ons cards for ports will enable high-speed transfers between external devices (i.e., cameras, drives, and computers), performance will vary depending on the special features of each type. FireWire, or FW400 (also known as IEEE 1394a or Sony iLink), was once common in DV/HDV camcorders, pro DSLRs, tethered microscope cameras, and external hard drives. It has since been replaced with the inexpensive USB2 or the faster FireWire800 (FW800 or IEEE 1394b). An advantage of FireWire is their capacity to "daisy chain" or link two or more devices in a series to a single port on the computer while operating at full speed. With USB, each device needs a separate port, and the transfer speed is reduced with the addition of each device to a port on the same hub.

When using one device at a time, USB2 is the most widely and easily available data port. The highest speeds are attained with USB3, which may be available in the latest systems. Fortunately, FireWire, USB3, and the even eSATA ports can be obtained with an ExpressCard adapter on some laptops and PCI cards on desktop computers (see Table 9, Fig. 36).

Figure 36. Examples of data ports. (A) Cable plugs: FW400, FW800, eSATA, SATA, USB (square and flat). (B) Cable ports. (C) Mini (video) and full-size (computer) plugs. (D) ExpressCard slot and adapter in a laptop computer.

3.6.2. Data ports for video

Common data ports such as USB and FireWire are frequently used for transferring video data from cameras to computers, but in some case are also used for viewing on computer monitors. For viewing on traditional (non-computer) monitors such as TVs, a video port is more likely to be necessary (Fig. 37). These range from analog wires and pins (RCA, VGA) to digital (S-video) and high throughput cables (component, DVI, HDMI, DisplayPort, Thunderbolt).

Table 9. Summary of modern data ports, including digital video and network.

Port (speed)*	Notes	Availability
USB2 high-speed (33 MB/s)	- for regular transfers: cameras, drives - can provide *low* power to operate device	most common in use for data transfers
USB3 super-speed (400 MB/s)	- fastest USB transfers - different shape but still fits USB1 & 2 - can provide power to operate device	new; may need an add-on card; may need drivers (if not natively supported)
FW400 or IEEE1394a (50 MB/s)	- link to miniDV cameras and older drives - use to "daisy chain" hard drives - can provide power to operate device	some older PCs or use card
FW800 or IEEE 1394b (100 MB/s)	- faster than FW400 - use to "daisy chain" hard drives - can provide power to operate device	some PCs or use card
eSATA (115-500 MB/s)	- high-speed transfers from SATA drives - short (1 m) data cable - needs separate power cable to operate	some PCs or use card
ExpressCard (130-300 MB/s)	- laptop expansion slot: USB3, FW, eSATA, SSD, memory cards, WiFi - may need separate power cable	2 slot sizes: 34 and 54 mm
DVI (500-1000 MB/s)	- connect digital monitors (replaces legacy analog VGA)	used for viewing on newer PCs
HDMI (1250 MB/s)	- akin to DVI, but includes multi-channel data and consumer copy controls - connect to TV or monitor for HD video	new PCs or use card; used to view and capture video
DisplayPort (1250 MB/s)	- similar to HDMI but royalty-free - connect digital monitors (not TVs) - **mini**DisplayPort = same physical form as Thunderbolt	full-size port on some high-end monitors (NEC, Dell); **mini**port on Macs and Apple LED monitors (pre-2011)
Thunderbolt (1250 MB/s) bidirectional: 1.25 GB/s data, 1.25 GB/s video	- proposed to replace others: FW, USB, eSATA, VGA, DVI, HDMI, DisplayPort - daisy-chain with peripherals, displays (data and video simultaneously) - 10 W power (no AC adapter needed) - currently over short copper cables; eventually to use longer optical cables	new chipset by Intel (cannot be added to old computers); first seen in MacBook Pros and hard drives (2011) with other storage devices; video capture decks and cameras to follow
Gigabit Ethernet (125-1250 MB/s)	- higher-speed network cables: Gigabit found on computers, 10 GigE on servers	add-on card for 10 GigE; used in high-end cameras

* Estimated transfer speeds will vary between technical specifications and real world use and version (eSATA I and II, DVI single- and dual-link). To assist in discussion of file sizes, transfer speeds are stated in *Megabytes* (**MB**) per second, instead of *Megabits* (**Mb**) (1 byte = 8 bits).
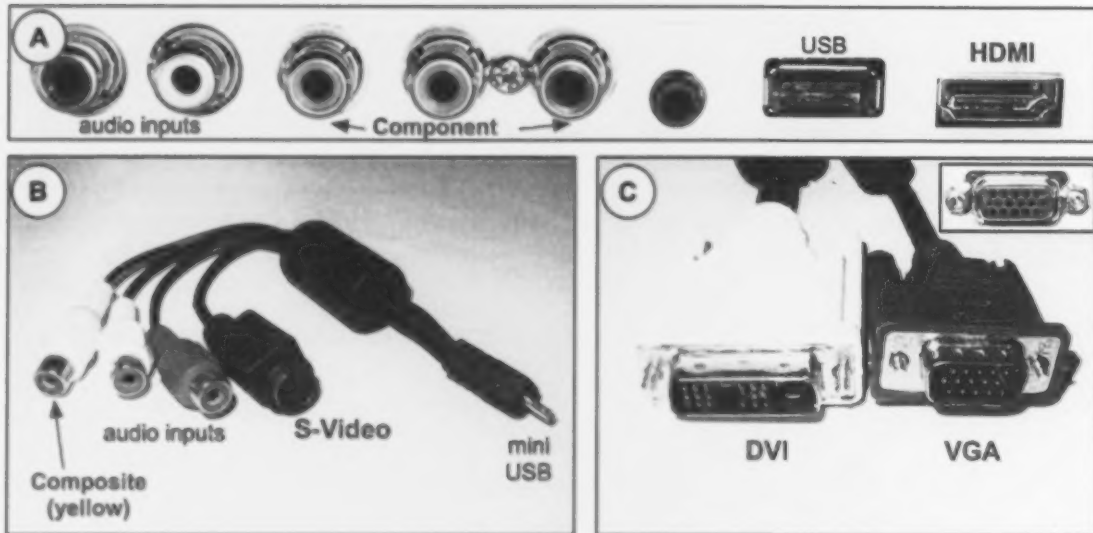
Figure 37. Examples of video ports. (A) High-end video (component, HDMI). (B) Basic video (composite, S-Video). (C) Computer monitor connections (DVI, VGA).

The presence of legacy video ports such as RCA and VGA has persisted in many computers and monitors despite the availability for several years already of high-end digital standards (i.e., DVI, HDMI, DisplayPort). An example of an advanced data and video port was seen with the release in early 2011 of Intel's Thunderbolt (previously named Light Peak). Hardware controllers enable highest-speed bidirectional transfers of computer data and video data without the need for software drivers as it makes use of available internal hardware (PCI Express, DisplayPort). Currently, the Thunderbolt plug has the same form factor as the miniDisplayPort seen on recent Apple computers (Fig. 38). Adapters are not needed to make use of it as a DisplayPort (data use requires an actual Thunderbolt port). Currently, the Sony Vaio Z21 is the only non-Apple PC with Light Peak, although Intel will make it available to other PC manufacturers in the future.
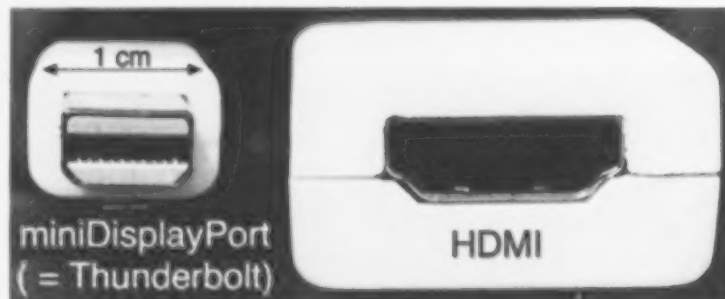
Figure 38. Comparing sizes of recent plugs and ports: Thunderbolt and HDMI.

3.6.3. Data ports for image transfers

For images and videos, regular network (Ethernet) and USB2 cables are frequently used in file transfers. Better performance can be achieved with faster cables (USB3, FireWire800, Thunderbolt) and networks (GigE). While sustained transfers are fastest with physical cables, data may also be streamed wirelessly (Wi-Fi) for small-scale activities, such as individual photos, video clips, and media catalogs. Comparisons of data ports for file transfers are shown in Fig. 39. Information on remote (cloud) storage is presented later in Section 3.8 (Data storage).
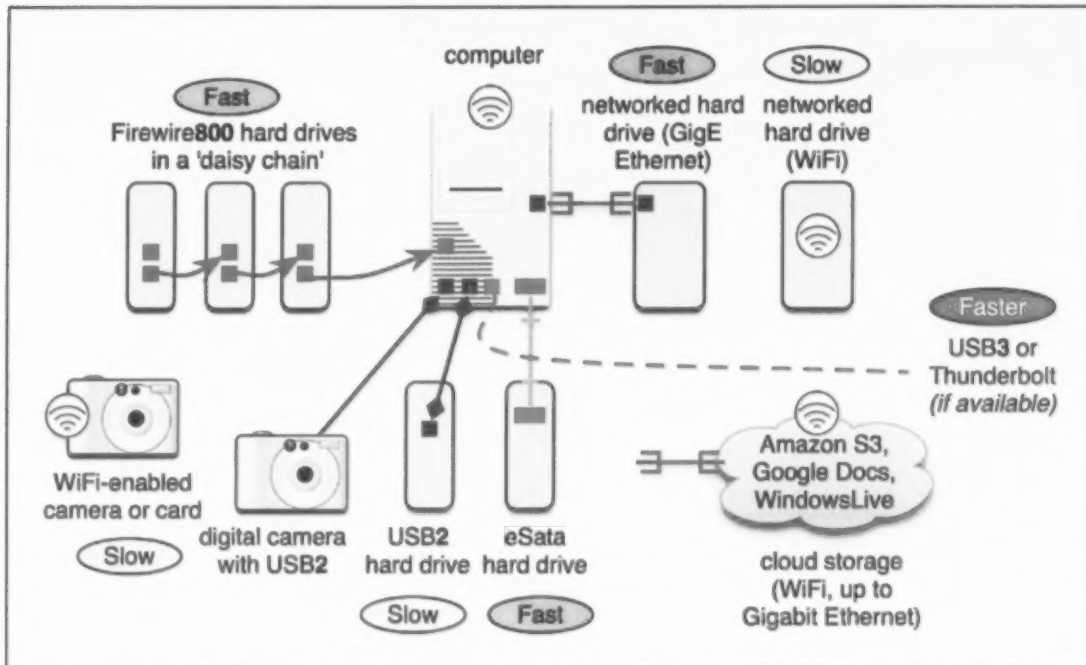
Figure 39. Linking devices for data transfers.

3.7. Video Monitors

Fortunately for science work, LCD monitors are now inexpensive and available in large sizes. Large screens (20 in and greater) are easier to work with during image and video analysis because less time is spent scrolling, zooming, and changing windows. Flat LCD monitors also increase efficiencies by saving space and using less electricity than the older CRT monitors. More recently, LED lights have been replacing the fluorescent-backlight in LCDs. These LED-lit flat-panel monitors are slimmer still, with greater energy efficiency and longer life, making upgrades even more appealing (Fig. 40).
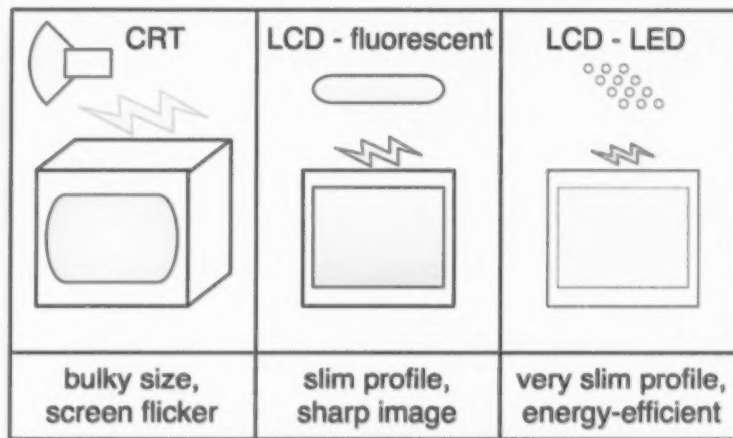
Figure 40. Video monitor types: CRT, fluorescent-lit LCD, and LED-lit LCD.

Apart from screen sizes, monitors are available in standard or high-end colour models. Higher-end monitors include LCD monitors with IPS panels instead of the standard monitors with TN panels, enabling better viewing and colour. Current examples are Dell Ultrasharp monitors and the iPad tablet. Standard office monitors are good for general video and image analysis. Photographers may prefer higher-end monitors because these have wider colour spaces (for highly saturated colour), more levels (finer image tones), and consistent viewing at wide angles. A comparison of other features of these two classes of monitors is given in Table 10.

Aside from monitor type and quality, monitor calibrations are also required to ensure consistency when editing images on-screen and making prints. If work projects require colour consistency, a monitor calibration device is used to correct the factory settings and apply a standard colour profile such as sRGB (or AdobeRGB in high-end monitors) (Fig. 41). Calibration is performed on new monitors (corrections from factory settings) or periodically to correct for shifts in colour that occur over time—mainly with CRT, but also with fluorescent-lit LCD monitors. Note that calibration tools may not work on the newer LED-lit LCDs, although these screens are usually more uniform and consistent in light output to begin with.

Table 10. General comparison of LCD monitor classes and features.

Feature	General	Professional graphics
Video port	VGA, DVI, HDMI	DVI, HDMI, DisplayPort, Thunderbolt
LCD panel type	TN (inexpensive)	IPS (better viewing angles and colour)
Fluorescent-lit	Inexpensive	Wide-gamut colour output with special tubes
LED-lit	Slim, uniform light (no warm-up), less energy	Still new – unknown if able to calibrate for colour or achieve wide colour space
Colour space	sRGB (standard)	sRGB, AdobeRGB (wider colour range)
Levels	8-bit; millions of colours	10-bit; billions of colours
Calibration	Need external tool	May include hardware profiling tools
Use	Video and image analysis	Critical analysis and printing of high-bit files: RAW photos, professional broadcast video
Min. price (2010)	$200 (24 in)	$700 (24 in), $1600 (30 in)
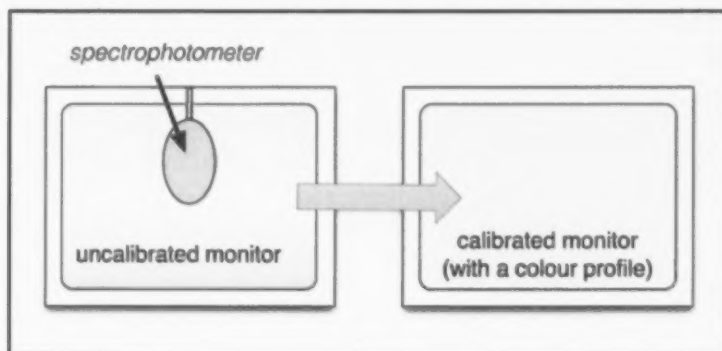
Figure 41. Monitor calibration and colour profiling. A device (spectrophotometer) is placed facing the screen to evaluate the output and adjust to a standard profile.

3.8. Data Storage

Storage is yet another field in technology that changes often. Over time, storage capacities tend to increase exponentially while the cost per unit of storage space gets cheaper, thereby enabling the storage of ever-greater amounts of image data. More space allows for more image files with higher resolution and less compression. Decisions to discard, reduce, or compress files with data loss become less urgent with increases in capacity and reduced costs. Concerns remain, however, regarding the preservation of storage media and their readability by future systems.

Storage of image data currently can be grouped into four types (Table 11):
- magnetic **hard disk** drive (HDD)
- **optical** disk drive (DVD, Blu-ray)
- flash or **solid state** drive (SSD)
- **network** services (via Ethernet and Wi-Fi)

Table 11. Summary of storage options for image data.

Type	Advantages	Disadvantages	Use
Magnetic disks (hard drives)			
3.5 inch hard drives	Large capacity (>1 TB), low cost	Spinning platters: vulnerable to vibrations, overheating, mechanical failures	Working on files, archives and backups on externals
2.5 inch hard drives (laptops)	Compact form, energy efficient, may be powered by USB	Higher cost per unit stored, may be slow (5400 rpm), vulnerable (vibrations, failure)	Working copies of images data files in the field (transfer to drives at the office)
Disk arrays: RAID, JBOD, Drobo*	Linked for speed, capacity	Amount of work to set up and maintain varies with linkages	Backup, storage, processing HD video
Optical disks			
DVD writer (4–7 GB)	Inexpensive removable media	Insufficient capacity for large project files, slow to read and write, vulnerable to damage	Archives of image and compressed video files
Blu-ray writer (25–50 GB)	Larger capacity media	Relatively slow and high cost of media	Archives of RAW images and HD video
Solid state (flash memory chips)			
USB thumbdrive, memory cards, SSD	Compact, easy to operate, stable (non-magnetic)	Highest cost per unit stored so large capacity is rare; harder to erase securely	Image capture device, computer boot drive (faster)
Networked (Ethernet and Wi-Fi)			
Local area network (LAN)	Locally provided (workplace)	Speed (depends on local network connections)	Backup services of local files
Cloud storage (by cable or wireless)	No physical media to handle	Speed (depends on wireless or network connections)	Secure off-site backups

* RAID: Redundant Array of Independent Disks (software or hardware system to use several drives)
JBOD: Just a bunch of disks (attached, but no system to manage them)
Drobo: Data robotics (commercial brand of easy-to-use RAID hardware systems)

Most current desktop PCs use 3.5 in "fast" 7200 rpm (or less commonly, 10 000 rpm) **hard disk** drives. The smaller profile (2.5 in) and slower 5400 rpm drives common to laptop computers are usually cooler, quieter, and more energy efficient (better for battery life), although 7200 rpm models are now also available for faster read/writes. Because they use spinning platters, hard drives are prone to mechanical failure and not appropriate in demanding environmental conditions (vibration, temperature, magnetic fields) such as those that may be encountered with bottom dredges and towcams, for example.

Writing on **optical** media is a useful backup for magnetic disks. However, optical drives are also vulnerable to vibration, causing read and write errors with the laser reading of the disk. Optical disks are also sensitive to physical handling (scratching), heat, and sunlight when unprotected. Most importantly, they are very slow to read and write, and have much smaller capacities relative to hard disk and flash drives. For smaller backups (or larger projects when using Blu-ray), writing optical disks remains a valuable option.

The decline in the cost of flash memory for computers and mobile devices has enabled the emergence of **solid state** "drives" (SSD), which are basically memory chips on a card. With no moving parts, these storage devices are more energy efficient and many times faster than spinning drives. However, the much higher cost and lower capacities of SSD relative to hard disk drives mean they are best used in special functions, e.g., underwater cameras, where battery power and vibrations may be important limitations. Computers may also being equipped with SSDs internally, as a boot-up/applications-only disk. A computer can read and open software many times faster when the system and application files reside on an SSD, while the large files (i.e., photos and videos) are kept on a more economical hard drive. This increase in performance is useful for demanding tasks such as when working with an advanced image and HD video editors.

Most PCs, even laptops, can be upgraded to receive more or larger capacity drives. In some cases, it may be easier to add drives externally, linked with a data cable. Smaller projects may begin with one or more hard drives with a USB2 cable. Larger groups will save time during file transfers with special linkages, for example, using eSATA, FireWire800, USB3, Gigabit Ethernet, Thunderbolt, or disk arrays such as RAID (see Fig. 39, Table 11).

Large and fast hard drives can be noisy, generate heat, and take up space. Another external storage solution is to have someone else link boxes of disks together and sell their extra capacity available on a **network**. While workgroups and institutes usually have storage available on internal networks, the rapid development of so-called "cloud computing" means that storage on external, commercial providers such as Windows Live, Google Docs, and Amazon S3 has become an easy and cheap way to backup image data, as a complement to hard drives and optical disks. For small volumes of important image data, the option of using "outside" storage for project files may provide valuable insurance against data loss for a project. For larger data volumes, such as HD-video, it may be more cost-effective and easier to back these up using manual "sneakernets" (transporting drives off-site, e.g., walking over in sneakers).

4. WORKFLOW

4.1. Workflow Needs

As outlined in Section 2 on image data, working on files refers to several different types of tasks (Fig. 42). For efficiency and optimal visual quality, suggested recipes or workflows may be examined to perform these tasks. Fortunately, a good number of books are available detailing such workflows, often shown with examples for popular software such as *Photoshop* or *Lightroom* for photos and *Vegas Pro* or *Premiere Pro* for video. While these guides are great resources for tips on getting the most out of software, their immediate value for science projects can be less obvious, especially as most guides target commercial photographers, with tips on image capture and editing. In contrast, for science work, all stages may be important, but the time and resources available for work are often greatly restrained. This leads to the necessity to identify needs and plan strategies using workflows.
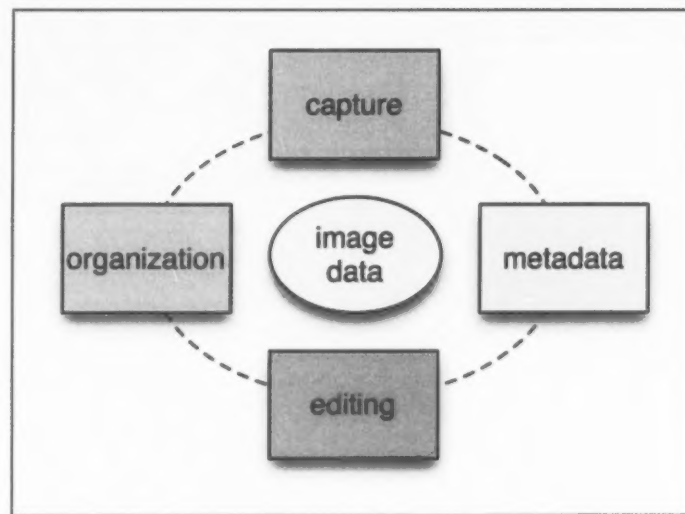
Figure 42. Workflows for image data revolve around capturing files, compiling metadata, editing (processing) images, and organizing (archiving) files.

4.2. Workflow Strategies

Not all image data is obtained in the same manner, nor do they serve the same needs. Establishing an appropriate strategy is necessary when adopting a workflow. Initial questions that should be asked include:

- How much time is available for different work stages?
- What resources (in equipment and software) are available to perform tasks?

- What are the current expertise and possible training requirements?
- How will the data be used, and what is needed in terms of metadata?
- Where will the data be archived, including originals and versions (exports)?
- How to address storage needs for large volumes of digital files?

For projects where image data may only be one of the assets in science work, discussions of imaging principles and workflows can be overwhelming. The example projects in the next section (Section 5) demonstrate that implementing a workflow to obtain good image data can be practical and beneficial, and not overly demanding in time or effort.

In more advanced projects, once again, the options and choices available in forming a workflow are daunting, and strategies will need to be developed to optimize work effort, or time spent, and the quality of results. The example workflows presented in Section 5 are often suggestions for minimal requirements, which may be expanded when time allows or needs arise (e.g., for exporting metadata, optimizing visual quality).

As outlined in Fig. 43, different projects will identify work stages, tasks, and tools, depending on means and goals, but the workflows presented here as examples can be derived from this basic "recipe."
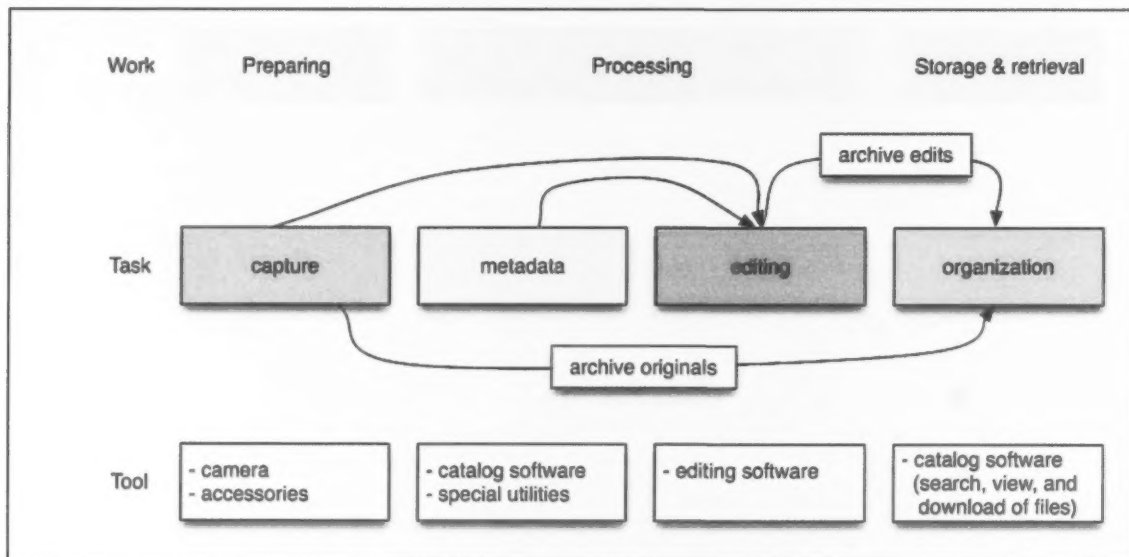
Figure 43. Generalized scheme of working with image data.

4.3. Capture Workflow

In the days before digital devices, capture on film required a degree of preparation and waiting for results, whether it was to take a photo of a specimen in a microscope or conduct an aerial survey. Current imaging devices are more automated and the results are available for review instantly. In addition, digital files are often more forgiving when it come to their processing, with lighting and lens corrections now widely available in software. One result is that processing images "post-capture" receives a great deal of attention relative to the work during capture itself. Indeed, obtaining images and videos in the field and the lab can be a relatively quick and inexpensive affair compared to the work, time, and resources that may be spent dealing with the files afterwards. In many cases it is too late—editors and managers of image data have to "make do" with what is received. Where the option exists to prepare, certain general practices will assist in capturing quality image data.

4.3.1. Accurate documentation

Metadata is the storage of information with images files. At the moment of capture, information on date, time, location, and subject may be available but very quickly forgotten or lost. Prior to capture, the camera should be verified for date and time zone, a GPS device or other location reference should be prepared, and subject or extra information (e.g., station, context, scale, contact) should be noted (such as a label in the image field of view.). Data may be more difficult to obtain afterwards, so some degree of redundancy is often valuable, for example by noting time and date by hand or by computer, to complement the camera timestamp in case of errors, thereby avoiding time-consuming efforts at estimation (Fig. 44; see also Appendix 3).
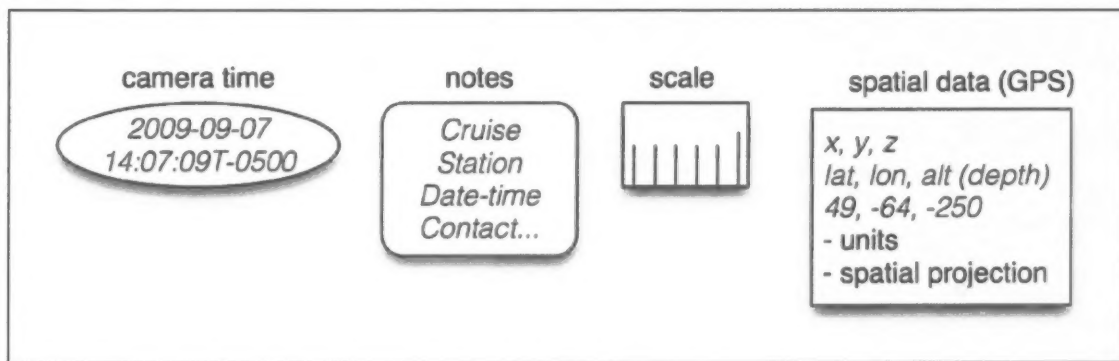
Figure 44. Examples of image references during capture. Information based on date, mission, size (scale), and location add value to the images during capture.

4.3.2. Lighting

With outdoor work, lighting may not seem critical or even controllable, but harsh conditions require some adaptations, especially where bright skies or ice and water dominate exposures with dark subjects such as seals and whales. Indoors, capturing images is challenging due to dark conditions, such as in the hold of a ship or in a laboratory. Extra lights and camera flashes require testing to see if they are sufficient for large objects and not overwhelming for smaller ones. Supports like tripods may be used to hold a camera steady, but they are unwieldy when in a helicopter, onboard a ship, or at the lab. In these scenarios, preparation may involve mini-tripods or improvised supports (e.g., beanbag, elbow, or countertop).
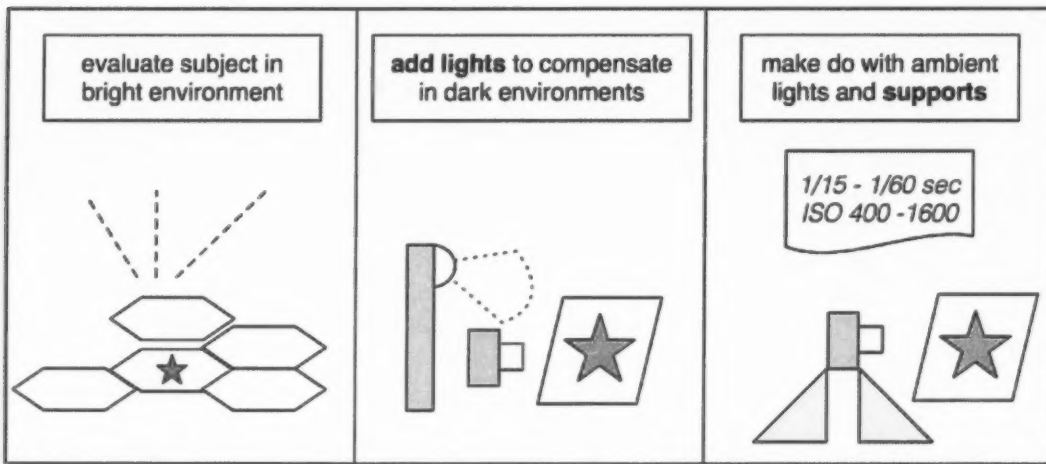
Figure 45. Evaluating the light environment in preparation for image capture.

4.3.3. Camera settings

Because of the vast numbers of models of digital cameras, nearly all of which have automatic functions, it is not always apparent how to be familiar with their operation. In some cases, automatic functions may not be desired, and some understanding of controls for flash, ISO, shutter speed, and focus is desirable. Depending on the subject (e.g., macro vs. outdoor landscape) and quality desired (quick jpg with high ISO vs. RAW or multiple shots with bracketing), even automatic cameras may have settings that should be examined and prepared prior to capture (Table 12). The consequences of choosing camera settings will be demonstrated in the next stages of the workflow: image processing and editing (also see work examples in Sec. 5.4).

Table 12. Capture preparation: suggested camera function settings.

Function	Purpose	Comment
ISO (sensitivity)	Reduce image blur due to slow shutter speeds	High ISO leads to increased image noise (especially with small cameras; larger-sensor cameras are more forgiving)
Aperture	Large depth of field with small aperture	Small apertures give sharp details, but require more light/slower speeds to avoid camera shake blur
Shutter speed	Reduce image blur with action or small aperture	Handheld shots need higher speeds (or increased ISO) to avoid blur
File type	JPG, RAW, JPG+RAW	RAW+JPG gives flexibility: JPG is ready immediately, archival RAW is for quality
File quality	Lossy compression of JPG	Use maximum quality (high or superfine) unless memory card space is limited (does not apply to RAW, where all is conserved)
File size	Number of pixels in JPG (e.g., 4000 × 3000)	Use full size whenever practical (does not apply to RAW, which is always full size)
White balance	Set for light conditions (sun, fluorescent, etc.)	Use **"auto"** (underwater: "daylight") when taking JPG (not necessary for RAW)
Exposure (+/-)	Compensation for auto-metering in bright conditions (cloudy, sunny, flash)	Defaults may try to preserve highlights with low detail (clouds, flash reflection), although subject is dark and detailed; consider "bracketing": multiple shots at +/- 1 EV for JPG (+/-2 EV for RAW)
Macro focus ("flower icon" on most cameras)	Close-up shots (usually less than 10 cm).	Lens distortion and difficult exposure (flash or shadows) may occur if too close; try focusing from a small distance with a small amount of zoom

4.4. Processing Workflow

In a basic work setup, image processing and editing refer to the same set of tasks: receiving image files and applying some changes or corrections—usually exposure and colour (white) balance. For larger projects, it can be efficient to break down the work with some tasks performed automatically, upon import, or in batch soon afterwards. Processing work is thus after the image capture, but before applying edits to individual images. As with the image capture, certain settings and some preplanning will assist in the processing workflow for:

* ingesting (importing) files and applying preliminary edits
* applying meaningful naming conventions and organizing files (tagging)
* generating image previews (especially important for raw files)
* establishing metadata presets to perform these tasks
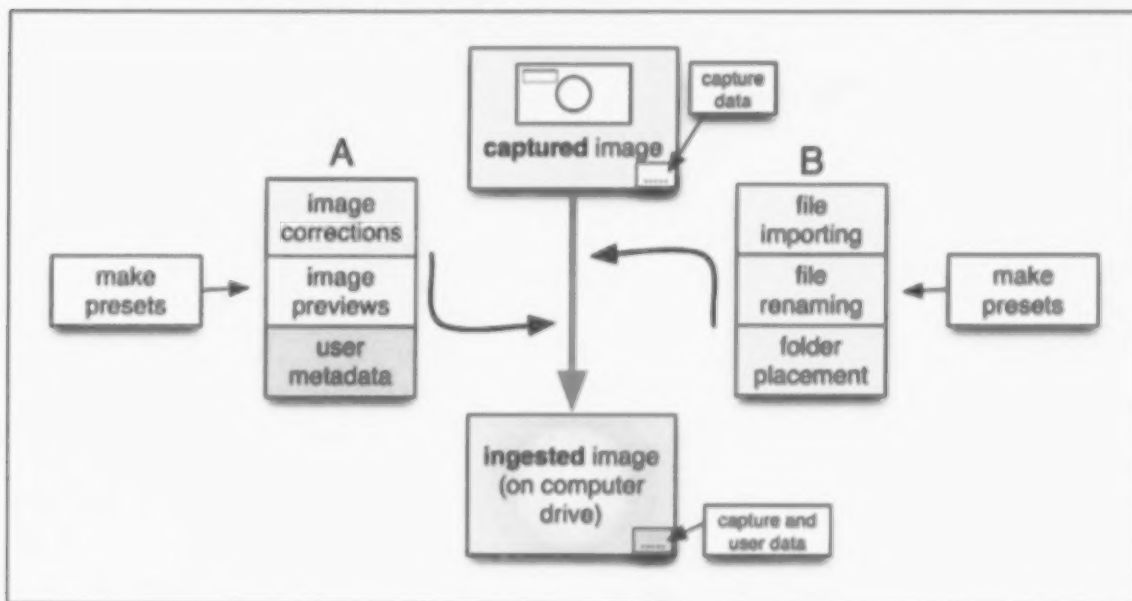
Figure 46. Processing workflows.

As seen in Fig. 46, several processing actions may be performed automatically when **ingesting** (importing) a set of image captures from a camera to the computer. A) Typical actions include basic image corrections (e.g., exposure), full-size JPG **preview** creation (especially for RAW files), and **tagging** with minimal user annotations, such as creator, contact, location (station). B) The ingestion process is also a good time to rename files and to direct copies be made in different folders and drives. With repeated intervals, i.e., by stations or work periods, image ingestion may make use of **presets** to apply the processing work (corrections, metadata, renaming, and file placement). See Appendix 1 for a file naming example.

4.5. Editing Workflow

Once image files have been received and initial processing has been done, further editing may be undertaken to improve the image. Traditional processing edits at this stage in the workflow include:

- adjusting or completing initial edits (exposure, colour balance, contrast)
- editing for image quality (lens corrections, detail sharpening, noise suppression)
- editing for metadata (filling-in user annotations and correcting default metadata)

These types are listed because editing refers to different kinds of work for different users. In addition, most photo tools offer flexibility to edit using a variety of methods. As a result, image editing "recipes" will vary with software and user experience. For science work, it is more important to recall the main principle from Section 2.4: always work in a "non-destructive editor" (see Fig. 19) or else work on copies, never the original files.

Metadata tagging may also receive a different emphasis than is often seen in photo workflows. The use of keywords and other annotation fields enhances the scientific value of image files, arguably to a greater extent than image corrections, because it enables sorting and filtering by type and quality. For dozens or a few hundred files, memory and quick visual review often suffices, but quickly becomes easier with metadata tags. Unfortunately, as with image editing, tagging can consume a great deal of time when trying to fill all available fields. A diminishing flow approach is more efficient, applying general tags to groups at first, adding more tags (or edits) as needed with ever-narrower groups of files (Fig. 47).
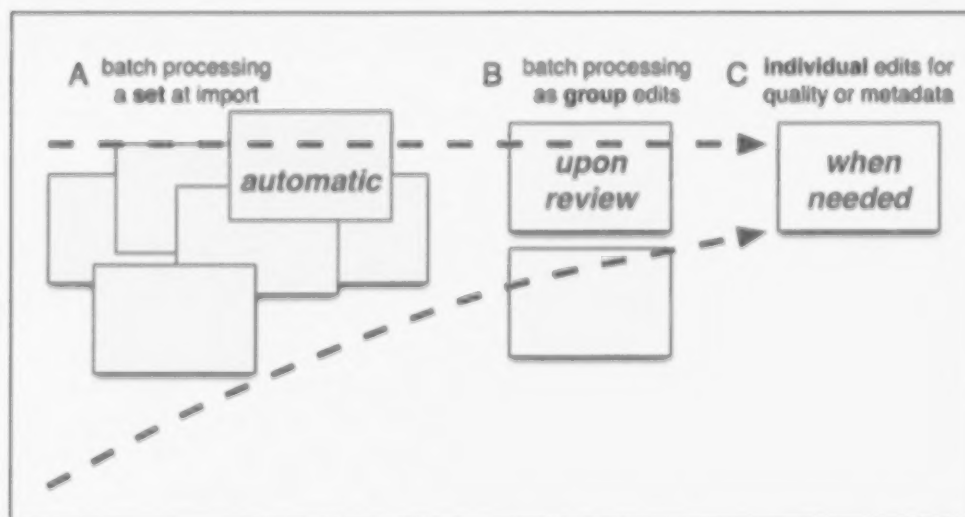
Figure 47. Editing stages for images and metadata to lessen workloads. (A) General tasks are applied before (or soon after) file import, (B) with additional edits applied to smaller groups after review, or (C) to individual files as necessary.

4.6. Archiving Workflow

Storing, or archiving, image files may be considered the end of the image workflow. However, it should also be considered for its broader role at other stages, for example, as original backups following capture and intermediate backups during image editing, in addition to their use as collections and catalogs.

collections (virtual groupings or folders of image files)
catalogs (documents of image files, metadata, and collections)
backups (working and archive copies of files and catalogs)
exports (versions and derivatives of image files and metadata)
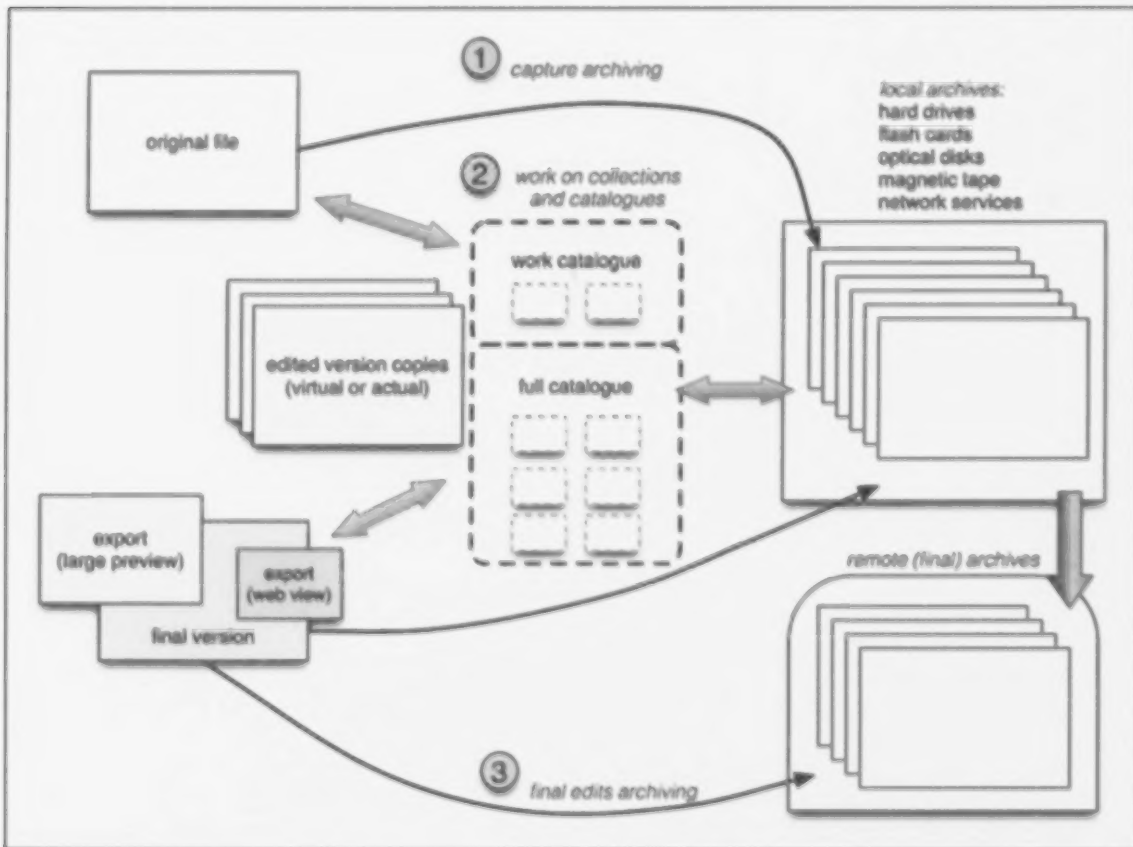
Figure 48. Archiving work takes place at several levels: 1) backing up original files, 2) saving work in collections and catalogs (i.e., previews, group tags, and virtual copies), and 3) saving final edited "best" and exported versions.

4.7. Workflow Summary

The preceding discussions have set the stage to put into practice the general principles from Sections 2 and 3 with the tasks outlined here. Examples of two classes of workflow schemas are shown in Fig. 49. Lightweight projects look to the protection of captured data with backups, minimal editing, and storage, thereby ensuring best quality for future work if need arises. Advanced projects undertake more preparations for capture, tag-ingested files with metadata, edit with parametric (i.e., non-destructive) tools, and storage in collections for archiving.
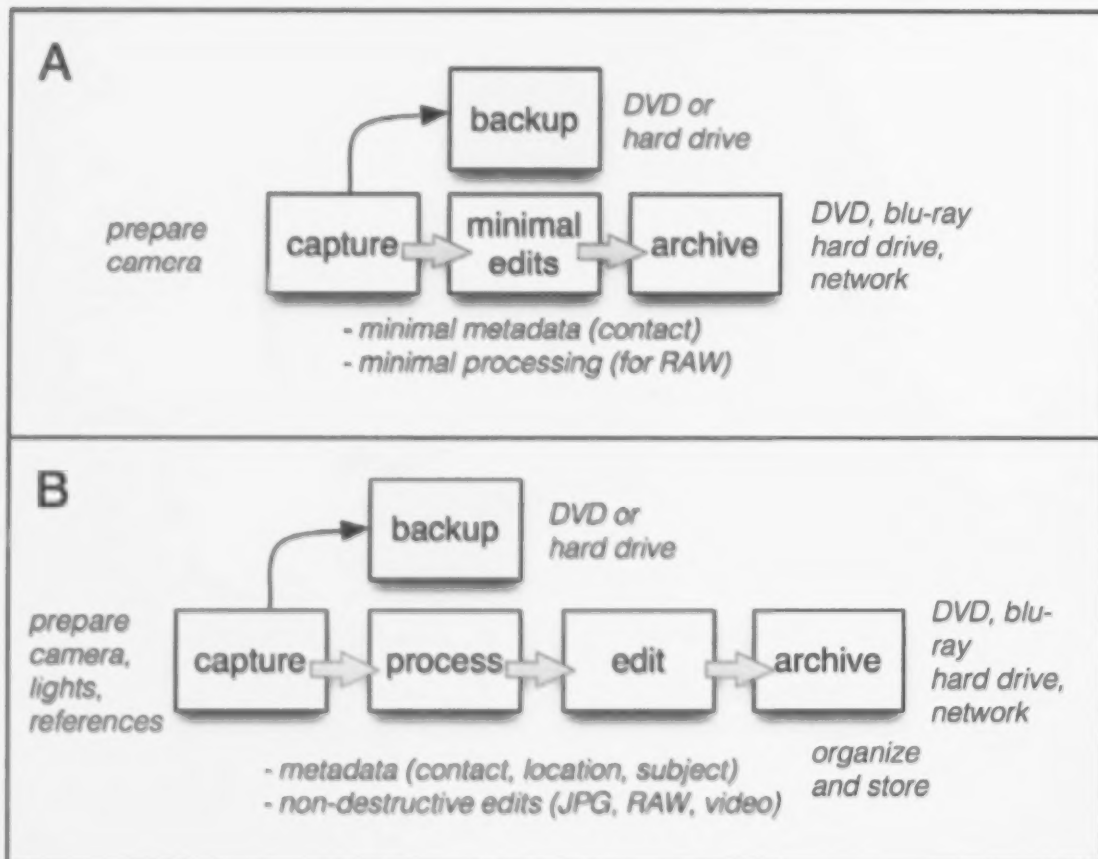
Figure 49. Workflow schemas for (A) lightweight and (B) advanced projects.

The following sections will demonstrate specific examples of workflows by subject type (Section 5) and software tool (Section 6), and finally as published archives (Section 7). Further information for working with digital data is presented in the reference books, such as Krogh (2009) and Laskevitch (2010).

5. IMAGE DATA PROTOCOL EXAMPLES

A series of workflows for laboratory and field activities are presented as short summaries and case examples. The examples demonstrate work procedures and software options that may be helpful for handling image data; they are not intended as strict requirements.

5.1. Laboratory: scanning photo media

Photo film libraries may contain a wealth of image data, including aerial breeding seal surveys, lab photos, or general photos of activities. Compared to videotape media, film products may be more stable, but there is still a need to digitize to preserve and make available historical images. However, the time needed to scan individual items makes it important to form a strategy, to decide how much is realistic to achieve. External service houses, with high-end scanners, may be called upon to achieve best results with important transparences such as pinniped (breeding seals) recounts on a sequence of frames. With general photos, scanning can be performed relatively quickly and easily on a consumer flatbed scanner. In most situations, the effort involves scanning and cataloging the media, without image corrections (to be performed later on, if needed).

Workflow summary

evaluate scope of digitizing: time, cost, quality, storage, distribution

scan physical media with highest quality

rename scanned images and tag with minimal metadata

store backup files on optical disks and hard drives

edit images (corrections, cropping, extra metadata

5.1.1. Stages in scanning photo media

Image capture
1) If part of a large collection, choose files to receive priority for digitization
2) Choose means: outside service or in-house scanning

Film transparencies (negative strips, positive slides)
- Blow-brush transparency surfaces
- Load transparency into film carrier
- Set file format for RAW, 16-bit TIF, or highest-quality JPG
- Scan at highest resolution DPI:
  - 2900 to 5700 for 35 mm frames in film scanners
  - 1200 to 4800 on a flatbed scanner

Prints (reflective scanning)
- Wipe clean glass surface of flatbed scanner (dust and paper particles may accumulate between scans)
- Place print flat on glass surface and close lid
- Set file format as TIF or highest-quality JPG if unavailable
- Scan at 600 DPI resolution for detailed images, 300 DPI for regular prints

Image cataloguing
3) Rename scanned images with useful, incremental names
4) Tag files with minimal metadata: event, date, contact, location, subject (Fig. 50)
5) Backup project files to DVD and an external drive
6) Correct images (cropping, light, and shading) with editing software
7) Export smaller versions of image files for regular viewing
       e.g., 800 × 600 or 1600 × 1200 JPG

Tip: default metadata from scans hold little information, making user-added annotations even more important (Fig. 50).
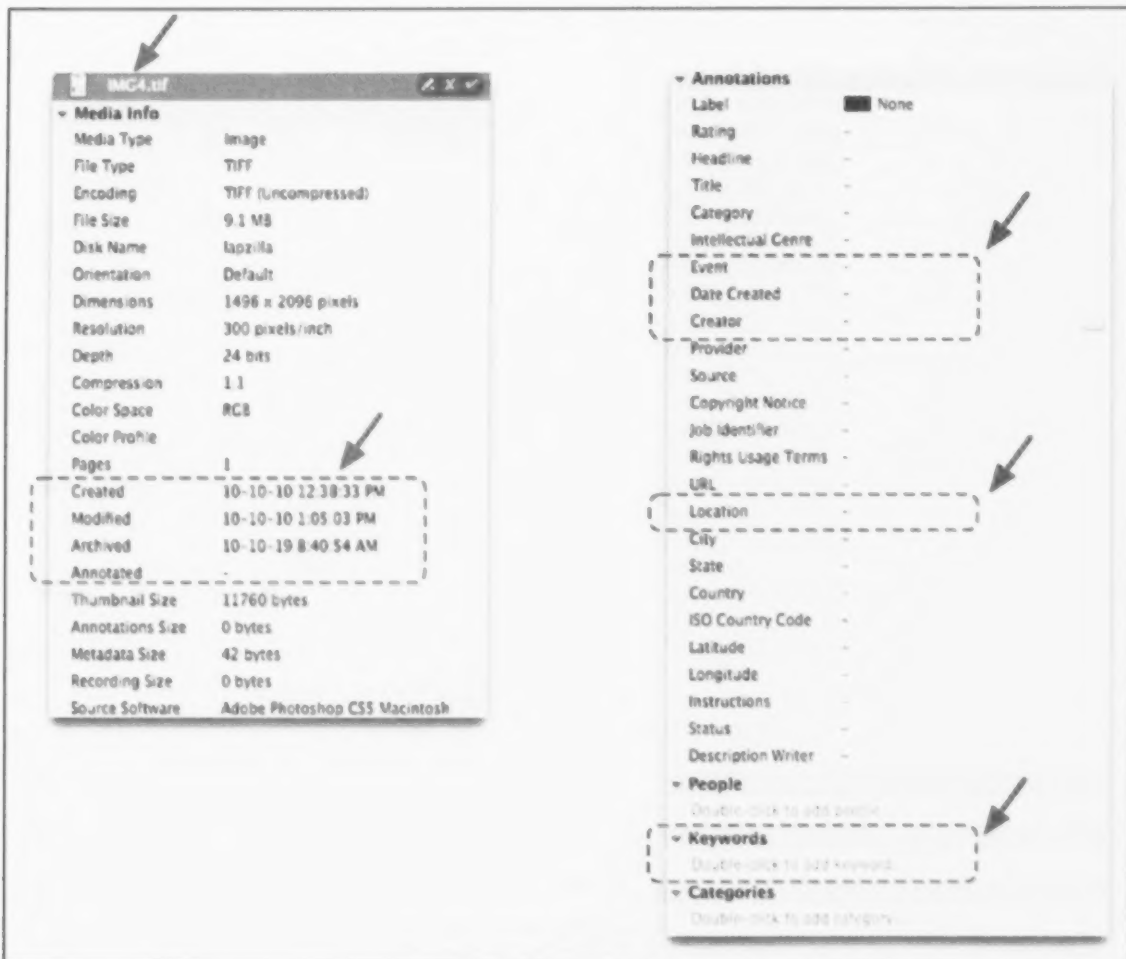
Figure 50. Metadata for scans. Red (left): file name and scan capture date. Blue (right): fields to fill in with metadata such as original creation date, creator, and subject.

5.1.2. Tips for scanning

Batch renaming and file tagging is important because the default names and capture metadata is limited in scanned files (Fig. 50). Default filenames and creation date will be based on scanning date, although editing to a relevant name and date may be preferred.

Orientation of the print on the scanner is not important since minor edits are almost always done afterwards (i.e., rotation and cropping). Reminder: if editing is done on JPGs, use highest quality level or save as a compressed (LZW option) TIF.

For additional information, see the SIWG digitization guidelines at:

http://www.digitizationguidelines.gov/guidelines/digitize-tiff.html

Case example – camera and copy stand for digitizing collection specimens

Institutes house flat items in their collections that may be digitized either by a flatbed scanner or a camera on a copy stand. Some setups can be attained at low cost (less than 100$), but higher speeds and quality scans require more investment. The camera and stand option is especially interesting for high volume work (Fig. 51), as may be the case with image plates, such as fish scales or otolith photographs.

Workflow

- *Prepare label with printed barcode using software*
- *Place label with specimen on copy stand with lights and a small colour chart*
- *Photograph in RAW with a DLSR camera and sharp lens, e.g., 50 mm macro.*
- *Read barcode label by scanner (or by camera, if so equipped; see below)*
- *RAW files sent to incoming folder are renamed with barcode*
- *Minimal metadata is tagged to photo file with software*
- *Export a JPG for viewing in a collection and archive RAW files*
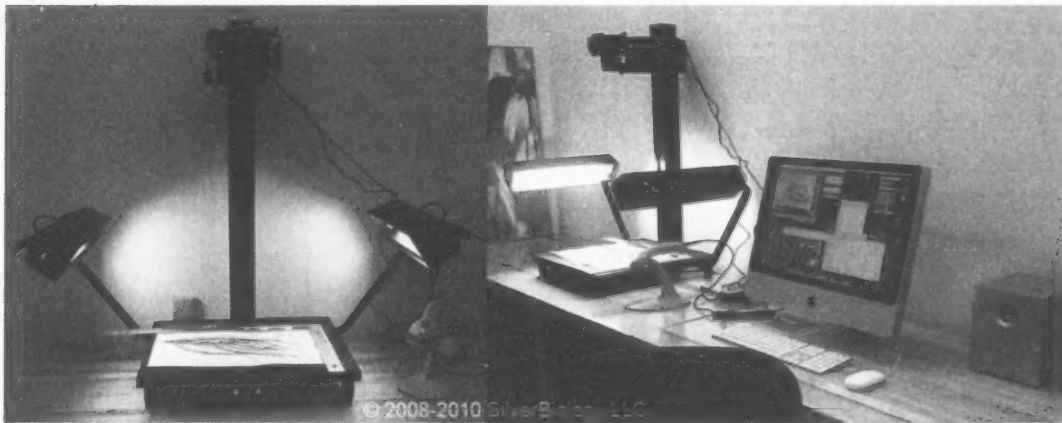
Figure 51. Setup for high-volume digitization of collection materials with *SilverImage*.

Tips for digitizing on a copy stand
- Automating will greatly increase capture and processing speed of samples, at rates of several dozen per hour and up to several hundred per day
- DSLR camera may be remotely operated by software (tethered)
- Some DSLRs (Canon, Nikon) can now incorporate barcodes into files
- Capture software can monitor incoming files and rename and tag automatically
- Reserve special effort for priority items (type specimens, etc.)
- General items may be digitized in bulk with simpler cameras and software

Recommended resources:
Steinke et al. 2009.
http://www.canadensys.net/digitization/imaging
http://www.silverbiology.com/products/silverimage/

Case example – flatbed scanning plankton for automated plankton classification

Flatbed scanners may scan samples of zoo- and phytoplankton with automated classification analysis tools. The freeware *Zoo/PhytoImage* is currently available for Windows XP systems.

Workflow

- *Install software packages and manual from http://www.sciviews.org/zooimage/*
- *Calibrate scanner to determine size of pixels and levels of gray (see manual)*
- *Set scanner for 16-bit gray, 2400 dpi TIF (RAW if available)*
- *Groups and larger taxons may scan at 24-bit colour, 600 dpi high-quality JPG*
- *Rename files according to date and mission (see manual for examples)*
- *Archive original full-size scans before image processing*
- *Process images with a training set*
- *Process images with automatic recognition for composition*
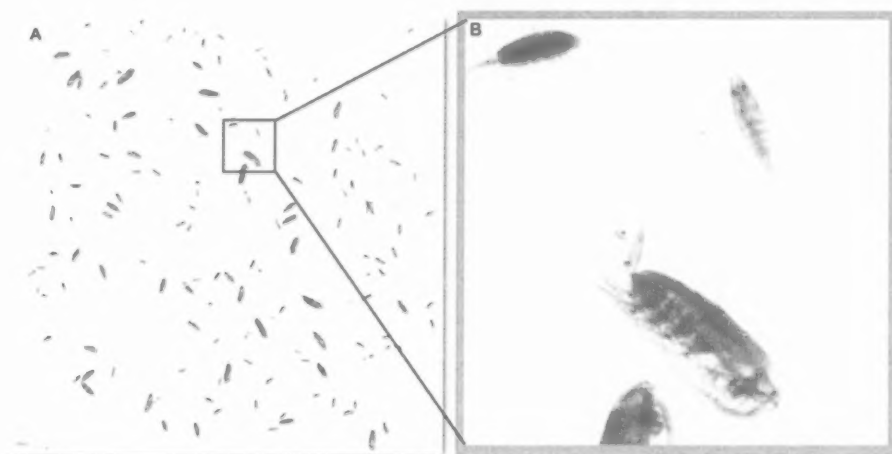
Figure 52. A flatbed grayscale scan of copepods. (A) Scanned sample dish. (B) Close-up view of inset. Source: Plourde et al. 2008.

Recommended resources:

ZooImage Forum
http://zooimage.overchord.net/forum/viewforum.php

Plourde et al. 2008. AZMP Bulletin 7:42-47

5.2. Laboratory: digitizing VHS video

Quantities of VHS videocassettes are produced in activities such as fish gate monitoring or submersible dives. These tapes have to be played back in real time and the signal "digitized" (captured) in order to be viewed, edited, and cataloged in digital media collections. Another issue is that magnetic tape degrades with time and humidity (White et al. 2007), and thus digitization may be undertaken to preserve the video data.

The best and easiest way to digitize videocassettes is to use a specialized service, but with fees of $10–20 per cassette, it may be advantageous to do the work with consumer tools. The amount of time and effort involved in digitizing should also be weighed in consideration of the original content or quality of a tape recording. Video from VHS is of poor quality and low resolution relative to digital and HD video. Content may also be of low value, depending on conditions during recording, such as murky, underwater scenes. With a potentially high cost to low value of the resulting image data, it is crucial to carefully plan and consider the options before embarking on a digitization project.

Workflow summary

evaluate scope of digitizing: quality, time, cost, storage, distribution

convert videos at highest quality using the available tool

rename digitized clips and tag with minimal metadata

store on multiple media (optical disks, magnetic drives)

distribute previews with catalog

5.2.1. Stages in digitizing VHS cassettes

Video Capture
1) If part of a large collection, identify which tapes are to have **priority** for digitizing
2) Digitize tapes using an **external** service (funds) or do it **in-house** (staffing)
(see steps of alternate pathways below and Fig. 53)

Video Cataloguing
3) Establish a plan to rename clips and chronology, i.e., capture date, not digitized date
4) Tag clips or DVDs in catalog software with metadata: event, location, contact
5) Archive clips or DVDs (backup on DVD or Blu-ray and hard drives)
6) Export small clips and catalog for desktop browsing and previewing
7) Export catalog metadata to a project database (*Access, MySQL, Oracle*)

5.2.2. Alternate pathways for VHS video capture

External service – DVD. *Best results: saves time, but costly.*

1) Send colour-critical cassettes for digitization
2) Choose output format (DVD, or any preferred format computer files)
3) Collect related data (date, location, event/cruise, subject/species, creator)
4) Catalog DVD or computer files with data in a media archive

Internal work – DVD. *Good results, but not easy to edit or manage as clips*

1) Select a cassette for digitization
2) Capture using a VCR with:
    - **internal** DVD player and recorder
    - **external** converter to a PC to record DVD (see Fig. 54)
3) Collect related data (date, location, event/cruise, subject/species, creator)
4) Catalog DVD or computer files with data in a media archive

Internal work – DV (AVI). *Good results, more work.*

1) Select a cassette for digitization
2) Connect with S-Video cable from VCR to:
    - a miniDV **camcorder** to Firewire400 port on a PC
    - a DV **capture box** to Firewire400 port on a PC
3) Capture video using:
    - **logging** tool (*CatDV Pro, DVMP Pro*)
    - **editor** (Premiere, Vegas)
4) Collect related data (date, location, event/cruise, subject/species, creator)
5) If desired, edit and convert (high-quality H.264 MP4)
6) Catalog file (original AVI or converted MP4) with related data in a media archive

Internal work – MPEG-4. *Results vary with settings; easy to store files.*

1) Select a cassette for digitization
2) Connect VCR to external converter and use best H.264 export settings (Fig. 55)
    - using S-Video cable (better quality, less common)
    - using RCA composite yellow cable (more commonly used)
3) Collect related data (date, location, event/cruise, subject/species, creator)
4) Catalog video files (MP4) with data in a media collection archive (e.g., *Expression Media, CatDV*)
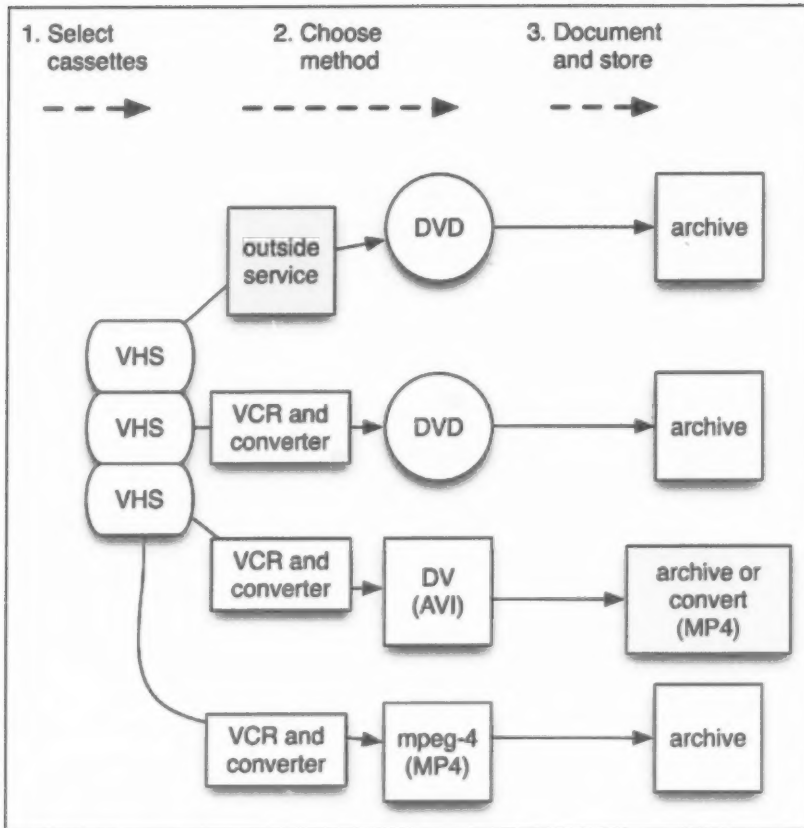
Figure 53. Alternate workflows for digitizing VHS cassettes. Options include sending to a service provider or doing it in-house with consumer converter tools, producing DVDs, large-volume DV (AVI) or compressed mpeg-4 (MP4) computer files.
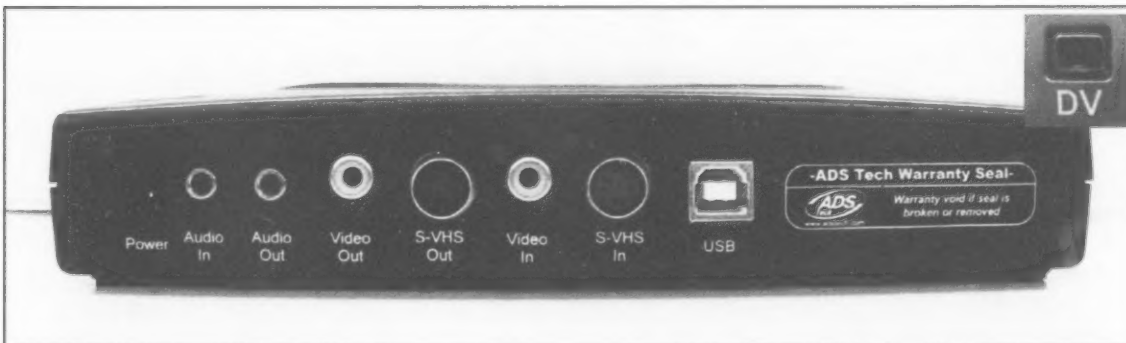
Figure 54. Video-to-DVD converter box. Ports include S-Video (round with pinholes) and RCA composite (yellow). FireWire400 is available by a mini-port in front (inset; "DV"). Output to computer is by USB2.

5.2.2. Tips for digitizing VHS video

Hardware and software converters

The work done by a computer to convert video can be performed on its own (using software) or with dedicated boxes containing processors to assist with the conversion. Hardware-accelerated boxes are useful in several ways. First, they can greatly reduce the amount of time needed to convert video files into compressed forms such as MPEG-2 and MPEG-4. The reduced time also allows for more advanced codecs to be used, resulting in better quality and more efficient compression of video files. Lastly, the converter boxes are likely to offer a variety of ports (S-Video, RCA, FireWire, USB), offering better signal capture from a source. Although such boxes may cost several hundred dollars, they may be necessary for work on older computers.

Software-only solutions also exist and are either free or inexpensive. These offer MPEG-2 or MPEG-4 conversions, but without chip acceleration and using basic codecs. The video produced is generally not of high quality and has increased blockiness and other compression artifacts. Current desktop computers (2010) are now powerful enough to convert using software, even with high-level codecs, but external hardware is still valuable for reducing processing time and for their legacy input ports.

Conversion codecs

The most widely available option is the conversion of VHS to DVD-video. The resulting MPEG-2 files on DVD-video are of generally good quality and relatively simple to view, on computers or disc players. However, there is some data loss during the capture and further loss will occur with subsequent edits and clip conversions. In situations with many hours of footage, as in monitoring, the loss of some data may not be an issue. For some clips, such as the time on the bottom during submersible dives, the ability to clearly evaluate content in a short sequence or to view image features frame by frame may be very important. In these cases, DVDs may be less satisfactory (compared to DV-AVI captures, for example).

The highest-quality captures (in MPEG-2 or DV50) normally require professional tape decks, like those used by outside services. More colour information may be saved and the resulting DVDs from these services will likely be of higher image quality than can be achieved with consumer DVD or DV converters. Again, the balance between quality and volume (number of hours to digitize) may determine the approach to use.

An alternative to DVD capture is to use a DV consumer set box or older miniDV camcorder with S-video input and FireWire output. Unfortunately, this legacy equipment may become increasingly hard to obtain and expensive compared to DVD and the more recent MPEG-4 converters. In addition, the FireWire ports used on DV boxes are optional on most PCs, requiring add-on cards whereas other converters operate on the common USB2 port. The advantage of DV (contained as AVI files on Windows systems; DV or MOV on Macintosh) is that individual frames are available in the captured video. Viewing frames and editing sequences of frames are much more easily performed with DV-AVI clips than with MPEG-2 streams contained in DVDs. In underwater surveys, the frame-by-frame identification and counting of benthos would likely be better served with

a DV-AVI capture instead of the mixed half-frames or blockiness when viewing a DVD or a MP4 file. However, in terms of preserving overall image quality, consumer DV tool boxes capture as "regular" DV (DV25), which retains less colour information compared with the DV50 codec of professional decks (used by the DVD service houses). Another potential issue is that DV-AVI file sizes are very large, with 1 hour of video taking up 13 GB of space, or about four times more storage than a DVD and eight times more than MPEG-4 files.

While storage costs are relatively small and there should be an effort to preserve image data, highly compressed files are easier to store with large clip collections. The MPEG-4 file is currently very popular as an efficient storage format. At its highest settings in the H.264 variant, it can present image data as good as MPEG-2 codecs, but with half the storage requirements. MPEG-4 performs lossy compression that may result in "blockiness," especially at lower quality settings and should be evaluated on tests before converting tapes. For example, the low resolution of VHS combined with the potentially low quality of filmed scenes (murky underwater footage, black and white or little colour information) may mean that questions about the resulting quality of digitizing to MPEG-4 are mostly irrelevant. Another potential advantage of MPEG-4 compressed video is that the associated format containers such as MP4 and MOV are capable of embedding metadata about the media and its content, thereby assisting with the cataloguing of clips when using collections software.

Managing data from analog sources
Metadata may require special efforts when digitizing tapes. Data, including timecode and GPS tracks, are not automatically available, but must be consulted from outside sources (i.e., project notes and files). In some cases, captured video may have had timecode and even GPS information visually "burned" (overlain); this is useful for viewing on-screen but not as data files.

Organizing video clips and project files may be as simple as using the file browser (Windows Explorer), but with dozens of clips and multiple events, it is best to use a software organizer. Most video editors have organization and tagging tools, for example *Adobe Premiere Pro, Premiere Elements* (budget tool), and *Sony Vegas*. These tools are intended to function on single workstations (a PC). For more advanced collections and shared catalogs, dedicated software may be necessary, from general packages such as *Expression Media to* video-oriented packages like *CatDV Pro*.

Video cataloguing programs are useful for organizing clips by date and project folders, renaming clips with incremental filenames (such as original dates/project name), and tagging with metadata. The range of technical information fields available in metadata can be daunting, and as with photo files, most data fields tend to be of interest to professional editors only. For scientists with the need to manage potentially large collections of clips, it is best to concentrate on applying a consistent system for file naming and folder organization. Optionally, software tools may used to embed minimal metadata (i.e., date, event, location, creator, and contact).

The option of tagging clips with metadata and organizing them in collections will bring the same benefits as when this work is done on still images, namely making it possible and easily to find and evaluate image files. The caveat with regards to video is that the standardization of metadata is not as advanced as with photos. While Adobe has their XMP and QuickTime has their format containing tags (i.e., location data in MOV), these are not always read outside of their software "family." Most video editors provide data fields that are either proprietary (closed) or that have an emphasis on sharing technical data between video editing packages. For science projects, it may be best to use cataloguing tools and metadata editors to read, write, and export the desired videoclip metadata, and then have this data from a clip collection linked to an outside database, rather than using tags. A practical example of this is the way *DVMP Pro* handles video files. This metadata tool correctly reads AVCHD files and embeds timecode and GPS information (when available), which otherwise may be lost or incorrect during the file import into a standard video editor. The conserved metadata can then be exported from the video and stored along with related files in a project database.

5.3. Laboratory: digital microscopy

Microscopes can be equipped with dedicated digital cameras (see note in Section 3.4.4 on equipment) that are linked to and operated by computer software while being viewed on a monitor rather than directly on a camera. The workflow is thus a bit different than when working with a handheld (or tripod-mounted) camera, in terms of software and metadata preparation.

Workflow summary

> *prepare microscope lights and camera software*
>
> *shoot several images at different focus points or stages*
>
> *transfer files and rename with enough increments to be unique*
>
> *tag images with related data (specimen name, specimen origins)*
>
> *send image files and related data to a digital image catalog*

5.3.1. Images for microscopy

More so than with other types of photography, lighting and focus (i.e., shallow depth of field) can represent challenges to obtaining good-quality images in a microscope. Digital microscope cameras allow for live previewing and quick evaluation of shots on a screen operated with the computer's imaging software, thus allowing for different preparations than are used with separate cameras.

Camera preparation
- **check image resolution** and **quality** settings (picture size and file compression)
  - most microscope cameras are set to low resolution by default
- plan on a **file naming** strategy before beginning, for example: date, specimen, station, number. *Examples: 20101001_Bugula_turrita_01.jpg, Balanus_2008_T13_09.tif*

Microscope stage accessories
- if possible, **avoid mixed lighting** (i.e., fluorescent and tungsten)
- place opaque specimen on a contrasting background (dark or light) with light above
- place translucent specimen on a frosted background with light above or below
- insert into the field of view a label, a scale bar, and a white balance or colour card

Image data
- image files should be the largest-size JPG or TIF possible
- place a label in the first shot for a sequence of images with the same specimen
- place files in folders by project and by date: e.g., Invasive species/2010-10-01
- **review** the images on screen as they are taken; check for lighting and focus

5.3.2. Tips for detailed and three-dimensional objects

Focus stacks and mosaics may be used to build a detailed composite of a specimen. (Fig. 55). The result has more depth of field and resolution (detail) than would be possible with just one image.

This technique is a good solution when limited by low resolution cameras (i.e., VGA or 1 to 3 MP microscope cameras). A mosaic of several 1 MP images is as effective as a 10 to 30 MP camera image.

Lens limitations (diffraction over f/11 aperture, narrow angle of field of view, soft corners and vignetting) may also be overcome by using focus stacks and mosaics.

For important specimens with a large amount of relief (3D), it may be worth the effort to take dozens of images, each with only a small change in focus or lateral distance, to produce one final high quality composite. Afterwards, these work stages may be discarded or conserved (for future processing) as a group in a catalog, alongside the final composition file (see Section 6.9. on *Helicon Focus* software workflow).
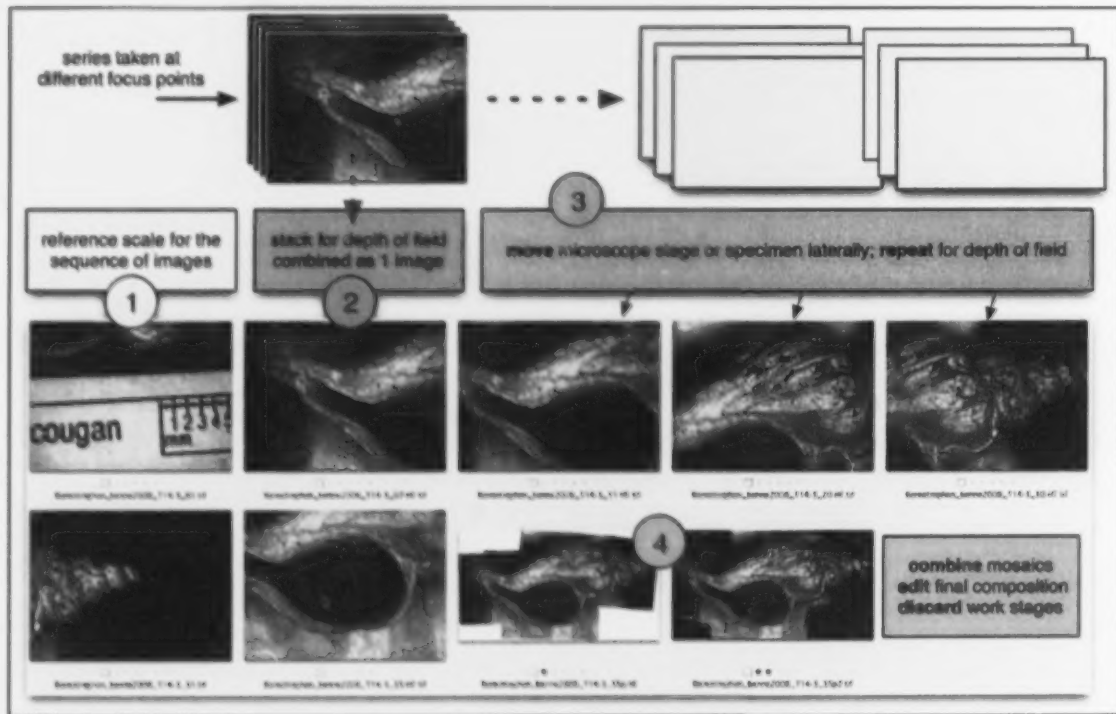
Figure 55. Steps in combining images with depth of focus and lateral mosaics to create detailed macro composites.

5.4. Laboratory: countertop photography

In the lab, biological specimens may be examined that vary in condition (live or conserved: formalin, ethanol, frozen) and interest for imaging. However, similar to on-deck photography, countertop work may be more "casual" as compared to photo surveys (aerial and underwater) or digital microscopy setups with their dedicated equipment and protocols. In this case, several steps may be followed to ensure good quality images and metadata while photographing in the lab.

Workflow summary

> *prepare cameras and accessories*
>
> *shoot images with even lighting and subject in focus*
>
> *transfer files and rename with enough increments to be unique*
>
> *tag images with related data (specimen name, specimen origins)*
>
> *send image files and related data to a digital image catalog*

5.4.1. Images for countertop work

Similar to photo microscopy, a series of images of larger specimens in the lab may produce valuable data, but handheld "countertop shots" often lack the focus and uniformity that can be had with the microscope's specimen stand and lighting. Whenever possible, avoid handheld work and plan on the use of lights, supports, and labels (for scale and reference). As the cameras used are often general-purpose, (i.e., taken outdoors, different users), always examine the settings before starting.

Camera preparation
- check **memory card** for space; delete files or format if necessary (see tips)
- check **date** and **time** on cameras as it may have been in a drawer for some time
- check **JPG image size** (megapixels) and **quality** settings (compression)
- check **white balance** – compare auto, fluorescent, or tungsten WB setting
- if **programs** are available, set to **Aperture** (A or Av) mode to control depth of field
- if **handheld**, **grip** camera correctly (see tips) and **raise** ISO (200+) to reduce blur
- if **fixed** using a tripod or stand, set camera with **low** ISO (80-100)

Camera accessories
- insert reference markers into the field of view, such as a label, a scale bar, and a white balance or colour card
- to reduce camera shake, use a small tripod, a beanbag or similar soft support
- use "daylight-balanced" fluorescent or halogen desktop lights, if available
- use a contrasting background (dark or light) with the specimen

Image data
- image files should be full-size JPG or RAW
- for a sequence of images with the same specimen, place a label in the first shot
- place files in folders by project and by date, e.g., Invasive species 1 / 2010-10-01
- **review** the images immediately as they are taken; check for focus errors
- **repeat** taking images with different focus and lighting if necessary
- delete extra images on the computer (not in-camera)

5.4.2. File renaming for lab photos

Laboratory photos may involve occasional contributions, over an extended period, taken by different people working in a lab. Consistent renaming of files is very useful, but may be difficult to standardize unless planned. In basic systems with only one camera in operation per day, the use of dated folders may suffice in the short term (no conflict possible with file names from two or more cameras).

- choose a renaming strategy if time and tools allow; otherwise:
- transfer files to a collection for renaming and file management (including tagging with minimal metadata)

5.4.3. Tips for countertop photography

Lights and flash
Portable light sources are useful to illuminate small subjects and fill in shadows. If no external lighting is available, camera flash may be used; however, close shots may be overblown, so be sure to review shots taken with a flash. If the camera has menu settings available, the flash intensity can be reduced or the shot underexposed manually. Another option for better flash illumination is to take the shot from a short distance while zooming in the lens for a close-up view.

Image noise and ISO
Photography guides usually tell the user to set their camera with the lowest ISO necessary to obtain clear, noise-free images. This was especially true for compacts (DSLRS have larger sensors and less noise). However, current cameras are producing good results at ISO 200, 400, and occasionally even higher. For handheld shots with average lighting indoors, increasing the ISO to may lead to an acceptable increase of image noise and a faster shot (higher shutter speed), and thus a better chance of a sharp photo instead of a noise-free—but blurred—shot at lower ISO (Fig. 56).
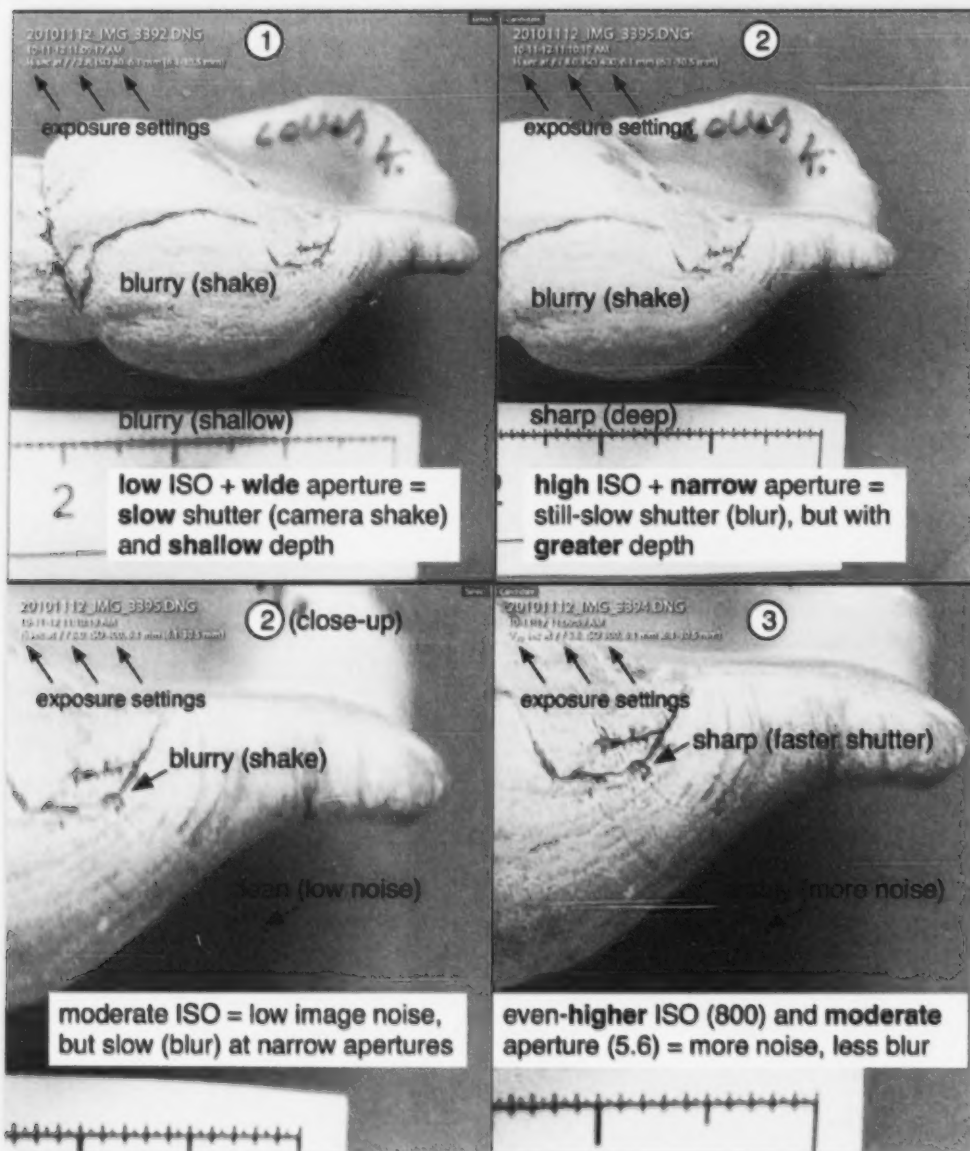
Figure 56. Compromises in handheld photography.

In the absence of strong lighting and camera support (tripod or stand), reasonable tradeoffs in image quality are undertaken for close-up photography (Fig. 56). 1) At low ISO, camera shake and shallow depth of field will result in blurred images. 2) Increasing aperture potentially offers more detail (depth), but may be lost due to blur. 3) Increasing ISO will reduce shake (blur), albeit with more noise, which may be acceptable in order to obtain sharper images with depth.

Aperture and depth of field

A side effect of the smaller sensors in compact cameras is a relatively large depth of field when compared to images taken with DSLRs. The result is that distance shots at f/4 and close-up shots at f/5.6 may suffice to show a subject with good depth of focus on a handheld compact. In comparison, a DSLR may need to reduce the aperture to f/11 or f/16 for a similar depth, which will require more lighting or slower speeds, and possibly the use of a tripod, stand, or flash. Thus, while large-sensor DSLRs and quality lenses have the potential for superior results, especially in colour range and pixel noise, compact cameras are generally easier to use for macro work, especially for casual use.

Tethering or wireless transfers

For judging focus, depth of field, and lighting, it can be helpful to have immediate views of photos as they are taken. Some compact cameras permit tethering with USB with live preview, albeit at low (VGA) resolution. More often, tethering results in after-capture views (high resolution), as is possible with Canon and Nikon DSLRs. Canon and Nikon DSLRs also offer wireless Wi-Fi transmittters as options. Another approach is to use memory cards that transmit images (Eye-Fi SD cards, Fig. 33), thereby enabling a number of camera models to transfer images wirelessly for reviewing on a computer monitor or a tablet computer. Examples include apps such as *Eye-Fi, CaptureOne Pilot,* and *ShutterSnitch* for the iPhone and the iPad.

5.5. Laboratory: underwater tank monitoring

Basins and swim tanks may be monitored during experiments to analyze swim performance and behaviour under different conditions. Video recorders are used to remotely survey the activity in a tank over the period of the experiment.

Workflow summary

> *prepare camera and cables*
>
> *deploy extra cameras for other view angles*
>
> *record video feeds*
>
> *export as clips in consumer formats*
>
> *catalog and archive clips*

5.5.1. Video from monitoring recorders

Network surveillance equipment often makes use of legacy (older) connections and proprietary recording codecs that may not be easy to transfer using normal tools. Other means of tethered video capture using consumer cameras and computers have the potential to produce high-quality video but may be difficult to operate continuously for many hours or days. Tethered cameras using cables for HDMI, FireWire, or USB cover only a few metres, while current network (Ethernet) and future optical Thunderbolt cables permit placement across rooms. Finally, a challenge with video monitoring is the need to efficiently store and manage many hours of recordings.

Camera preparation
- **determine** the needed distance for the camera to adequately monitor the tank
- for highest-quality stills (**frame grabs**), a tethered still camera may be used in time-lapse (intervals) or in video recording mode. Both give good results, but are limited to a short cable length
- long-term remote monitoring (i.e., computer at a distance form tank) is best done using network video recorders
- with a network recorder, multiple cameras can be deployed from several view angles
- **set date and clocks** of all cameras to computer time
- for standard TV video, set to North American NTSC 29.97 fps (not PAL 25 fps)
- save video feeds to recorder drives, or to fast hard drives when linked to a computer
- if feeds are not in a common format, export raw video with a popular *codec-container*, for example, DV-AVI (standard video) or H.264-MP4 (standard or for HD video)

5.5.2. Cataloguing for surveillance video

The value of recorded monitoring video is dependent on its management system to recall and search for desired sequences.

- if not already done by the recorder, rename video clips by date and sequence, and store in folders by experiment and date, e.g., Cod swim trials/2008-09-07/...
- for continuous video, use a clip utility to automatically generate breaks in video stream as individual clips, renamed by date and time, e.g., 20080808_140809.avi
- file browsers such as *Adobe Bridge* or multimedia cataloguing tools like *Expression Media* may be used to organize files into folders and rename in batches
- Advanced video organization and annotations may be achieved with a video cataloger (note: cataloguing software generally prefer MOV over AVI file containers; see software work example for *CatDV Pro* in section 6.7)

5.5.3. Tips for tank video monitoring

Video monitoring systems vary in light sensitivity and transmission options
- colour cameras are good in bright daylight operation
- lowlight CCD can operate in near darkness (0 lux)
- infrared-LED ring lights on infra-red cameras augment low light range
- network cameras run on Ethernet cables, with no need for electrical outlet
- Wi-Fi transmitter cameras are placed near an outlet, with no need for cables
- some systems are for live viewing, others include fully automatic recorders
- consumer systems are usually standard DVD resolution (480 pixels high)
- higher-end laboratory ("machine-vision") systems offer:
    o higher frame rates (60, 120, or more frames per sec)
    o greater resolution (1080 pixels HD and higher)
    o wider angle views (up to 360°)
    o operate over Gigabit Ethernet for distance, or Firewire and USB3 when near a computer drive
- uncompressed tethered video is very demanding for recorders to capture (data traffic) and store (file sizes), particularly for HD video
    o use of a compression codec (e.g., DV, MPEG-2, MPEG-4, M-JPEG) is usually necessary

Case example – Exclusion experiments with sea ducks feeding on mussels

Sea ducks foraging at mussel farm installations are a nuisance, with advice needed on effective deterrence measures. Physiological and behavioural experiments can be investigated with captive ducks monitored in a closed tank set-up (Fig. 57).
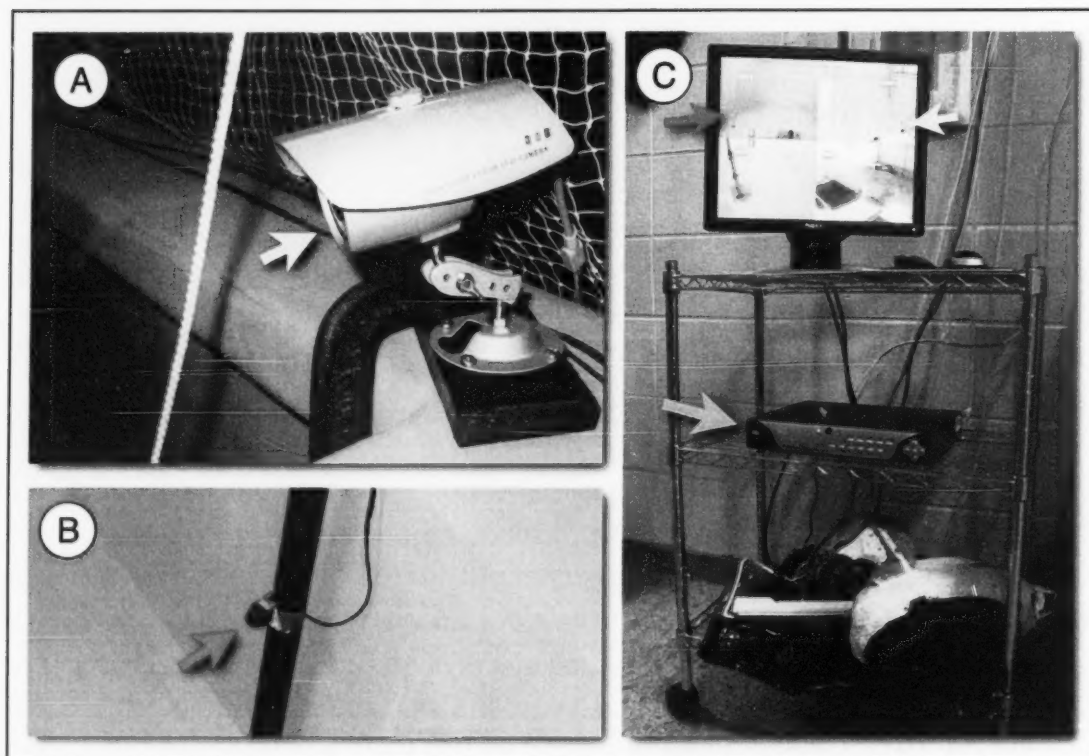
Figure 57. Video monitoring setup in a sea duck experiment. (A) Above-water camera. (B) Underwater camera. (C) Video recorder (pink arrow), with a monitor displaying the live view feeds from four cameras.

Workflow

1) Prepare network video cameras
   - lowlight camera used for 24 h monitoring of activity (A; yellow arrow)
   - underwater camera placed inside tank for monitoring dives (B; red arrow)
   - cameras operate on Ethernet with electricity (PoE: Power over Ethernet)

2) Record video
   - feeds saved to a stand-alone, hard-drive-based recorder (C, pink arrow)
   - video can be viewed remotely with computers on the network

- recordings saved for a week then overwritten if not transferred
- screenshots (frame grabs) taken from key scenes (dives) in videos

3) Archive video
- export videos as MPEG-4 AVI files (only option of the proprietary recorder)
- save AVI clips to external hard drives or burn optical disks
- edit AVI clips and screenshots for use in presentations

5.6. Field: diver underwater photo and video

Diver-held cameras have special considerations for managing the dive and image capture. Dive planning needs to take into account the additional burden or distraction brought on by filming while performing the usual dive tasks. Underwater image capture has special challenges in terms of lighting and camera handling, such as posed by restricted access to camera functions while it's in the waterproof case.

Workflow summary

> *prepare dive computer and outline tasks to be performed*
>
> *prepare cameras and accessories*
>
> *dive with camera and lighting; perform underwater tasks*
>
> *return and fill-out post-dive logbook*
>
> *transfer files and rename with unique ID*
>
> *tag images with related data*
>
> *manage transferred video files according to type and need*

5.6.1 Images and video from remote underwater devices

It is assumed that the cameras use solid-state storage (flash cards and drives)

Camera preparation (photo and video)
- for **DSLR**, select camera **lens** and case **lens port** (wide-angle = domed, normal = flat)
- **important**: check and clean camera case **seals** (O-rings)
- **check battery** level
- **check memory cards** for space; use **high speed** card for HD video (Class 6 or 10)
- prepare dive computer
- **set date and clocks** of camera and dive computer (GPS UTC is preferred)
- **check camera settings before sealing into case:**
    check image resolution and quality settings (if JPG)
    set to **auto focus**
    set **white balance** (underwater, daylight, or flash if JPG)
    set ISO speed (200–800) and **aperture** (A or Av) mode to control depth of field
    set camera screen to display "zebra stripes" (under/over-exposure warning)
- place a **label** or cue card identifying mission/date/dive station **in field of view** of video or photo camera at the beginning of the dive
- post-dive: **rinse** camera case with **freshwater** and **verify** memory card and battery before reusing on next dive

Tip: Condensation may take place in cold water if the lens port is colder than the case, as when using a plastic body with a glass lens port. Ways to prevent condensation include 1) inserting a silica gel packet in the case before sealing, 2) replacing the glass with a plastic port, or 3) using a metal instead of a plastic dive case.

Dive positioning
Spatial data preparation can take the form of simple notes (site marked in a logbook) or more detailed positioning.
• seal a compact GPS unit in a waterproof float to record a track as it floats on the surface while being towed during the dive.
• sophisticated acoustic positioning (similar to TrackLink) is also available for divers

Image data
• import files into folders by project, date, and station, e.g., mission X / date Y / station Z
• backup a copy of received image files
• **review** a subset of images: check for adequate lighting and focus (depth of field)
• if necessary, **adjust camera** ISO speed and aperture (lighting and focus depth) for a repeat dive or for the next station (note changes made)
• collect associated environmental data captured on dive computer for use in metadata

Video data
• import data folders or use capture software to transfer the files using high speed port (FW400, USB2, HDMI, Ethernet)
• **name folders containing** clips by project, date, and station
• backup a copy of received files
• **review** a clip or video sequence: check for lighting, field of view, focus, and image data quality (blockiness due to compression, noise, image stabilization; see tips)
• if necessary, adjust camera settings for next dive (note changes in logbook)

5.6.2. File renaming for diver underwater image data

• it may be useful to rename individual photos or clip sequences based on a chosen set of mission details and an increment, such as date x_dive y_number zzzz
• video clip renaming may have already been performed during the capture process from camera to computer (e.g., with *HDVsplit*)

5.7. Field: remote underwater photo and video

Apart from submersible remotely operated vehicles (ROV) and other live-tethered supports, underwater imaging entails preparation of cameras on a dropped or towed support and some post-analysis work.

Workflow summary

> *prepare cameras and accessories*
>
> *launch platform with cameras and lighting; retrieve platform*
>
> *transfer files and rename with unique ID*
>
> *tag images with related data (specimen name, specimen origins)*
>
> *send image files and related data to a digital image catalog*

5.7.1 Images and video from remote underwater devices

Previously, tape-based filming was common (DV, HDV), but it will be assumed here that current and future cameras used in underwater work are based on solid-state storage (flash cards and drives) or tethered remotely to hard drives.

Camera preparation (photo and video)
- **check memory cards** for space; use **high speed** card for HD video (Class 6 or more)
- **set date and clocks** of all cameras to GPS time on-board ship (UTC is preferred)
- **check image resolution** and **quality** settings (picture size and file compression)
- set **manual focus** and **lens zoom** settings for known height and field of view (calibrated prior to field operations by test filming in a tank); note settings for reference
- **set white balance** for the provided lighting (e.g., auto, fluorescent, daylight)
- set ISO speed (200–800) and **aperture** (A or Av) mode to control depth of field
- prepare data storage and clocks of optional **environmental** data loggers (depth, T°C)
- place a **label** identifying mission/date/station **in field of view** of video or photo camera **before** releasing the rig underwater (see tips for options)

Ship preparation (geospatial data)
Spatial data preparation is especially important when filming takes place over an area, i.e., along a transect, as compared to a single site or station.
- check that ship GPS data is being recorded, either as waypoints for stationary drops, or as tracks in transect tows
- note compensation factors such as cable length and depth, or use ultra-short baseline (USBL; e.g., TrackLink) to record precisely the vehicle's 3D position while underwater
- optional: take screen snapshots of acoustic depth finder during underwater operations

Image data
- import files into folders by project, date, and station, e.g., Cruise X / date Y / station Z /
- backup a copy of received image files
- **review** a subset of images: check for adequate lighting and focus (depth of field)
- if necessary, **adjust camera** ISO speed and aperture (lighting and focus depth) for a repeat dive or for the next station (note changes made)
- collect associated environmental data captured during dive for use in metadata

Video data
- import data folders or use capture software to transfer the files using high speed port (FW400, USB2, HDMI, Ethernet)
- **name folders containing** clips by project, date, and station
- backup a copy of received files
- **review** a clip or video sequence: check for lighting, field of view, focus, and image data quality (blockiness due to compression, noise, image stabilization; see tips)
- if necessary, adjust camera settings for next dive (note changes made)

5.7.2. File renaming for remote underwater imagery

- it may be useful to rename individual photos or clip sequences based on a chosen set of mission details and an increment, such as date x_station y_number zzzz
- video clip renaming may have already been performed during the capture process from camera to computer (e.g., with *HDVsplit*)

5.7.3. Image analysis

- see example protocol on image analysis for underwater photo and video in Section 6.11 (*ImageJ*).

Case example – ROV operation workflows

Data products from Remotely Operated Vehicles (ROV) are among the most complex to manage, in part because of the opportunities when using multiple sensors and the challenges of evolving standards and practices. For image data files (photos and videos), metadata such as timestamps are relied upon to maintain close association with dive logs and tracking files. In this example, the Pacific Region's Shellfish Division makes use of ROV surveys to acquire data on aquatic resources for DFO and other agencies.

Project image data:

1. Dive logs (*Microsoft Access* files from dive log computer to network database)
2. Tracking (geospatial files, GPX, and custom)
3. Video (SD, some HD, on MiniDV tapes, and stored on computer drives)
4. Photos (still images from ROV umbilical, USB wireless, and memory cards)

Other data products include sonar (Imagenix and Didson), CTD (Minilog, MiniSonde), physical samples, analysis (secondary) products, metadata, and protocols.

Summary workflows of the four core types of ROV data:

1. Dive log
Survey details recorded to ROV database.

Considerations for dive workflow and metadata
- Strive for a balance between collecting as much metadata as possible and the burden of filling out fields
- Presently evolving from earlier forms (paper, *Excel* sheets) to direct database import files

2. Tracking data
Navigation computer with *Trackman* to *Hypack* survey produce spatial files for use in other products (videos, photos, and database).

Considerations for tracking workflow and metadata
- Time data can be found in several files—and be different, offset, or wrong
- Synchronizing with UTC-GPS time is a key source of metadata for tracking software (*Tardis, GPS Clock, Hypack*)
- In some cases, time settings on equipment must be set manually
- Variations in tracking accuracy make it appear as if ROV is wandering when moving in a straight line
- Raw data overestimate distances, resulting in underestimated survey densities

- Data smoothing will suggest straight paths when actual track wandered
- Validating ROV movement by watching video is time consuming
- Track data quality over the course of survey years will need to be flagged (i.e., coarser resolution for less-reliable or older records?)
- In the end, an automated GIS solution is needed

3. Dive video

Capture video, record metadata, archive versions (original tapes and digital files), perform analysis, and export metadata for database querying.

<u>Considerations for video workflow and metadata</u>

- Video files have potential need for huge storage and transfer (speed) capacities
  - o Plan for the necessary overhead when starting a project
- Files can be corrupted or storage devices could fail (drive crash)
  - o Plan for redundancy (again: issues of storage volume and data transfers)
- Multiple copies may contain different portions of a dive (tape ends, device started later, malfunctions)
- On-screen coordinates (burn-in of lat/lon) may have errors
- On-screen time or date may not be correct or in sync
- Time in file name may not be correct
- Recording device time may not be correct

4. Dive photos

Capture photos, organize them in folders by dive, verify their EXIF metadata, geotag them, export versions of the photos for analysis and distribution of files, and export metadata for database.

<u>Considerations for photo workflow and metadata</u>
- Time sync issues
- Image capture (downloading) issues due to loss, corruption, or duplicates
- Partial capture of metadata (i.e., EXIF, datestamp) due to ROV software
- Work includes automatic and composed (manual) photos: need to identify types?
- Managing extra features: georeferencing, copyright notice, watermarking, keywording, and production of lower resolution distributed versions
- File naming and renaming conventions
- Retention of poor-quality photos or transit photos (e.g, taken during descent or ascent of camera to the sea bottom). To be deleted or simply marked for quality.

Case example – Capturing metadata from underwater digital video for archives

Capture metadata, namely the recording date and time, are important for digital video as reference markers during the analysis of video clips. Observations of organisms and bottom substrate are made while noting the capture time on-screen. For HD video, displaying time on-screen may be accomplished by several different means depending on the availability of computer tools and the purpose of the operation, such as generating clips for visual analysis, catalogs, or distribution (web, DVD, Blu-ray).

Project image data: underwater (bottom sled) video, HDV (1440x1080, 29.97 fps)

Workflow

1. Prepare videocamera clock
  - Camera clock is set to ship time (based on GPS) in order to be synchronized with other survey data (geospatial, environmental)
  - Alternately, a digital slate may be used to mark video timecode
    - o Acts as correct time reference when placed in view at the beginning of a recording (see Appendix 3)
    - o Some slates have the option to export their timecode to a video editor

2. Capture video
  - Tow camera sled for a 20 min transect
  - Camera tape data is captured to hard drive with *HDVsplit* utility
  - Clips are saved as HD transport streams (.m2t), renamed to include the recording date and time

3. Enable viewing of capture time for analysis; this step may take several routes:

Approach **A**: Rapid analysis (less demanding on computer to convert and playback)
  - Visually "burn-in" time and date to .m2t clips with *DVMP Pro* (see Section 6.6)
  - Output with DiVX or MJPEG to .AVI (relatively easy to process and read)

Approach **B**: Higher-quality intermediate (fast, larger temporary files, better quality)
  - As above, select *Lagarith* lossless codec for burn-in output (note: codec must be installed first; it is freely available online)

Approach **C**: Metadata saved as separate track (alpha transparency)
  - As above, check "*transparency*" and "*crop to metadata*" for output
  - In Lagarith "*properties,*" check "*RGBA*" (instead of the default "*RGB*")
  - Result is encoded **very** rapidly to a small black clip showing time only
  - Import the principal video clip into *Sony Vegas*, overlain with the burn-in clip
  - Output with any preferred codec (e.g., DiVX, MJPEG, MPEG-4)

Approach **D**: Direct use (easier to use when time comes to archive)
- Import .m2t clip into *Sony Vegas Pro* editor
- Import timecode from digital slate and reset video (timecode = recording time)
- On an empty video track, apply mediaFX "Sony Timecode" to display time (note: only video timecode is displayed, not recording date or recording time)
- Export output in an easy codec for analysis
  - o DiVX .AVI for viewing in *VLC*
  - o MPEG-4 .MOV for transcribing in *CatDV Pro Verbatim Logger*

4. Archive videos

Originals: HDV tape cassettes, .m2t clips on hard drive
- Retained for quality and completeness of data (future processing needs)

Image analysis usually will refer to edited clips with overlain time stamps. There are two main approaches to archiving this work on optical disks:

Direct (entire clip; no video editing): subtitled clips to DVD or Blu-ray
- Export time and date as subtitles from *DVMP Pro*
- Open .srt file with *Subtitle Workshop* (free utility), save as SonicCreator file
- Import .m2t clips and their .sob subtitles into *Sony DVD Architect 5*
  - o Make DVD (NTSC 720 × 480, 29.97 fps)
  - o Make Blu-Ray (HDV 1440 × 1080 × 24, 60i Blu-ray)

Indirect (clips processed with visual burn-in): edited clips to DVD or Blu-ray
- Import clips from either **A**, **B**, **C**, or **D** to *Sony Vegas Pro*
- Edit: trim clips, add titles
- Export *Vegas* edited clips to *DVD Architect* (Fig. 58, blue arrow) as:
  - o DVD project (NTSC 720 × 480, 29.97 fps)
  - o Blu-Ray project (HDV 1440 × 1080 × 24, 60i Blu-ray)

Computer player (mp4 clips): for ease of viewing in a media player
- Import .m2t clips to *Handbrake* (Fig. 58, red arrow)
- Export with preset for chosen player, e.g., iPod, web

Tips for videos clips and timestamps

Working with video often requires testing different steps for reasons of software compatibility or retention of features such as visual quality or timestamps (Fig. 58) and processing times. By retaining access to original clips and different versions, alternate work steps can achieve better visual quality, smaller file sizes, less work time, and more

data retention. While the following examples apply to HDV-type digital video, more recent HD video types, such as AVCHD, often follow similar processing paths.

Codecs
Installation of MainConcept or Elecard (both commercial) are recommended for HD decoding (to read HD files). For exporting (compressing), popular intermediate codecs include Avid, Cineform, Matrox, and Lagarith (open-source). Note that video editors may perform well when working with certain specific codecs, as in the case of *Sony Vegas Pro* using the Lagarith codec. Compressing with lossy (MPEG-2, -4, or M-JPEG) codecs is often easy as several of these may already be installed on the computer. However, their output will require either more processing time in subsequent editing (MPEG files), or give fuzzier text when burned in on-screen (M-JPEG files). It is recommended to experiment with codecs by exporting examples with a short test clip to evaluate them before applying a workflow to a project.

Retaining metadata
The above workflow example demonstrates ways to preserve and display capture date as visual burn-in, video text effect (i.e., timecode), or video subtitle. Burn-in is the easiest to see (analog), while subtitles are useful as data (digital). Analog burn-in also has the advantage of following the video clip through any editing, whereas digital data in the form of a timecode or subtitle file may be prone to corruption or loss when managed in certain video editors. A disadvantage of burn-in is that it requires converting the video clip and thus incurs computer processing time along with some data loss (visual degradation will depend on the choice of codec). By comparison, rewrapping a file (Fig. 58: black arrow, second yellow arrow) to a new format does not convert the video content, and therefore is much faster to process. As well, this method retains more visual data and metadata. In some circumstances, these rewrapped files will prove more beneficial for editing and cataloguing operations.

Cataloguing clips
Windows systems deal mostly with WMV and AVI clips as video containers. These formats may not be well-suited for holding capture- and subject-level metadata and, as a result, analog (visual burn-in) methods are often used to retain this information. For workflows to preserve digital data in the video file, a direct route is demonstrated here that goes from the original clip to a MOV container (black arrow, Fig. 58). Nonetheless, data such as recording date and time are best retained in external systems such as paper notes, *Excel* sheets, and GPX tracks. As a result, most video cataloguing efforts deal in organizing clips—originals and their smaller versions with visual burn-ins and appended filenames (second black and long yellow arrows, Fig. 58.).
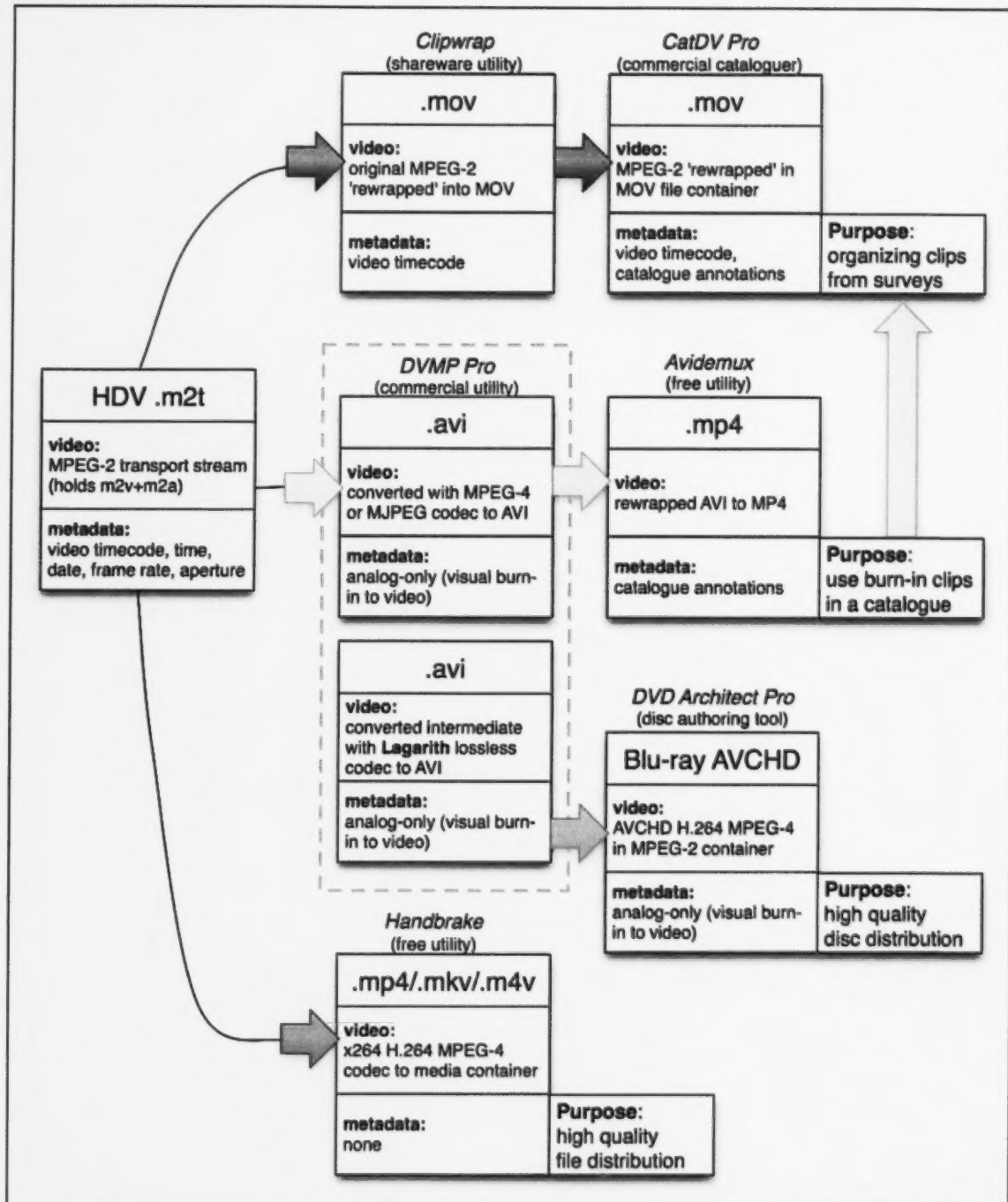
Figure 58. Alternate routes for handling video for image quality or metadata.

In Fig. 58, making use of files depends on features of codecs and containers. Black: fastest for cataloging; yellow: burn-in for video analysis; blue: archiving burn-ins with intermediates to Blu-ray; red: high-quality, unedited video files for distribution.

Case example – Surveying benthos of the Manicouagan Peninsula marine zone using field and laboratory images

A peninsula in the St. Lawrence estuary with a diversity of habitats and fauna, the Manicouagan zone was surveyed for its marine benthos, from the tidal shoals out to a channel of 300 m depth (for a summary, see Provencher et al. 2010). The collection of image data was done manually at first (i.e., *Windows Explorer* and *Excel* sheets), but later in the project, technologies became available for their management using databases (*Adobe Lightroom*, *Oracle* with *ArcGIS SDE*). Over the course of four years, the project combined image data from three different groups of benthic surveys: underwater tows, sampling at-sea, and laboratory examinations.

Project image data:

1. Underwater photos
Images in a sequence using a benthic camera sled towed on the sea floor
    - short transects covering entire study area (from shallows to channel)
    - second series of longer transects in the infralittoral (from 0 to 30 m)

2. On-board vessel photos
Hydraulic dredge and benthic sediment grabs / samples examined on deck
    - quick photos to document capture with fresh appearance (live colour)
    - reference photos to validate capture times, stations, and samples

3. Laboratory photos
Countertop (macro) and microscope photography of conserved benthos
    - physical details of specimens to document species identifications
    - compile photo catalog to minimize repeat manipulations, i.e., examination of specimens in storage freezers or boxes of vials with ethanol or formalin

Summary workflows
Images came from several cameras, but only one was in operation at any given moment, thus a correct timestamp should be unique for each image throughout the three imaging events (underwater, on-deck, in lab). All images were imported for management in a project *Lightroom* catalog, organized into folders by capture date, and renamed using "date-original file" (i.e., 20070916_IMGP158.JPG) unless files were already organized and renamed earlier, as in the case of the underwater sequences.

1. Underwater towcam workflow

Prepare Nikon D70 DSLR camera
    - Set camera settings: clock, manual focus, lens zoom, lens aperture, and ISO
    - Prepare flashes and the camera intervalometer (1 photo every 10 sec).
    - Seal camera in underwater housing with plexiglass dome

- Document camera settings in field notebook, i.e., lens and zoom setting used (for later calculation of the dimensions in the field of view of a photo)
- note: virtually all camera metadata, including lens information, can be read later in a program such as Lightroom. However, as a backup and for quick consulting, the settings should be written down in notes while in the field.

Document georeferencing method used
- Estimated position of sled relative to ship GPS using spooled cable length
- Recorded position of sled relative to ship GPS using TrackLink equipment

Import image files (JPG, or RAW when available) into a *Lightroom* catalog
- rename by date, mission, and transect, along with incremental numbers
- organize into folders by year (mission) and transect

Metadata editing in *Lightroom*
- tag all with keyword for mission, i.e., "underwater 2006," "underwater 2007"
- geotag EXIF using external software with GPS track or estimated coordinates
- tag in IPTC Location field by station/transect, i.e., "Station 03"
- tag by keyword of species name when viewed in image
- tag by colour label by type, i.e., good, murky, stationary (duplicate)
- tag by flag for notable scenes

Image editing in *Lightroom*
- correct white balance ("auto")
- increase exposure

Image analysis (counting organisms)
- examine corrected and tagged images in *Lightroom* catalog
- use a 24 inch screen to view library (grid) and another one for full-size (1:1)
- record counts by species in Excel worksheet

Export image data
- export JPG previews for distribution (web, documents, presentations)
- export image metadata from *Lightroom* using a plugin (*LR/Transporter*)
   o data fields of interest: filename, date, location, title, keywords, GPS
- import data into project database (*Oracle* + *Spatial Database Engine*)

2. On-board ship photo workflow

Prepare camera and reference points
- check camera battery, memory card, clock, and photo quality settings
- check if GPS track/waypoint information is available
   (optional: take photo of navigation screen for correct time and coordinates)
- prepare paper label of station, i.e., "Station B"
- review how to set camera on macro for close-up shots

Sample collection on deck
- first photo taken with label placed alongside general contents
- wash sample and photograph specimens with scale bar (and label if necessary)
- confirm on screen if photo is in focus (macro) and well exposed (light, dark)
- repeat photos to correct for focus and exposure (with shade, sun, or flash)

Import images for viewing on computer while at-sea
- transfer copies later to *Lightroom* catalog for editing
- rename by date, mission, and transect along with incremental numbers
- organize into folders by year (mission) and transect

Metadata editing in *Lightroom*
- tag all with mission keyword, i.e., "dredge 2006," "grab 2008"
- use reference photo with label to tag in location field, i.e., "Station 09"
  o optional: tag station name as a keyword
- geotag EXIF by station (in location field or keyword) using waypoints
- tag by keyword of species name when viewed in image
- tag by colour label for image types, i.e., doubtful identifications, error, good

Image analysis (validation)
- Evaluate identified organism in photo (confirm or correct species)
- Check for valid taxonomic names used in keywords
- Check stations with tagged photo on a map, i.e.*, Google Earth*

Export image data
- export JPG previews for distribution (web, documents, presentations)
- export image metadata from *Lightroom* using a plugin (LR/Transporter)
  o data fields of interest: filename, date, location, title, keywords, GPS
- import data in project database (*Oracle* + *Spatial Database Engine*)

3. Laboratory specimen photo workflow
(Note: small cameras easily obtain good results; DSLRs require more work)

Prepare camera and reference points
- check camera date and photo quality settings
- prepare paper labels with mission code, station, date, notes
  o optional: print scale bar on labels or use a ruler
- set up lights and backgrounds (light or dark, for bottom or sides)

Photograph samples with small camera or microscope
- place label and scale in first photo
- hand hold camera and use flash if 10–30 cm long
- use small tripod or stand, or on countertop if small (2–10 cm)
- support on a microscope if smaller than 2 cm

  o optional: take multiple images in series if microscope camera is low resolution (1–3 MP), lighting uneven, or focus shallow (specimen not flat)
- confirm images on screen (focus, lighting)

Metadata editing in *Lightroom*
- use reference photo with label to tag keywords (mission, station)
- geotag EXIF by station (in location field or keyword) using station waypoints
- tag by keyword of species name when viewed in image
- tag by colour label for image types, i.e., doubtful identifications, error, good

Image analysis (validation)
- evaluate identified organism in photo (confirm or correct species)
- check for valid taxonomic names used in keywords

Export image data
- export JPGs of identified specimens for a species photo collection with reference to stored specimen vials using metadata (i.e., mission, date, station, species).

Notes on the experience from the Manicouagan benthos image project

Underwater Video
From related survey work in the area (R. Larocque, 2010, pers. comm.), it may be presumed that the incorporation of video along with the vertical still images would have benefited in documenting certain species. Video offers a wide field of continuous images, thereby providing observations of large invertebrates (e.g., anemones and sea stars) that are interspersed on the sea floor and thus may be missed on the still image. Video also provides opportunities to document pelagic species of crustaceans and fishes that may be viewed rarely in photos at their rate of 1 frame every 10 sec.

Geospatial information
Photos may be taken after leaving the sample location, such as when receiving specimens on deck or later in the laboratory. In such cases, the time of the photo (timestamp) cannot be used to link the location with the time on a GPS track and the photo must then be tagged with coordinates manually. This procedure was easily accomplished by tagging photos with the name of a station in the IPTC location field, e.g., Station 13. The station name is known either by the photos' time (i.e., photos taken in the interval between station waypoints are of the preceding station) or by placing a paper label in the image. All images per station were then batch-tagged with the known station coordinates into the GPS fields of EXIF using external tools. The files were then refreshed in *Lightroom* ("read metadata from photo") and the information became available for viewing.

Underwater images were more difficult to tag geospatially. Unlike surface photos that are tagged by a single pair of coordinates (the station), the position changes in each

photo of the towed transect during the tow, and the location information will be important for spatial analysis (e.g., distance covered, density of organisms). Several techniques were used to locate the images on the seafloor—by compensating for the cable length of the towed camera sled or using an underwater positioning device (TrackLink). The GPS tracks recorded from the ship and the TrackLink were not always operational or complete. In cases of data gaps, the images were tagged with Google Earth, based on their timestamps and the time at known waypoints.

File renaming and folder organization

With ship and laboratory images, a variety of images are collected over a day, always using one camera at any one instant. The renaming of files and placement in folders was sufficient using dates and the original file name suffix. For example, using *Lightroom*, a file would be named 20070608_IMGP1023.jpg in the folder by year and day: 2007 / 2007-06-08. In cases with directed sequences of images, such as the towcam on underwater transects, it was deemed useful to rename images using the mission and station codes. The filenames and folders (by year and station) could then be quickly reviewed with *Windows Explorer* without having to open *Lightroom*. To help with sorting of files, including exported copies, renaming by stations was done consistently with leading zeros, for example as "04" and not "4" in the file name MCG2007_E_04_0_DSC_0285.DNG.
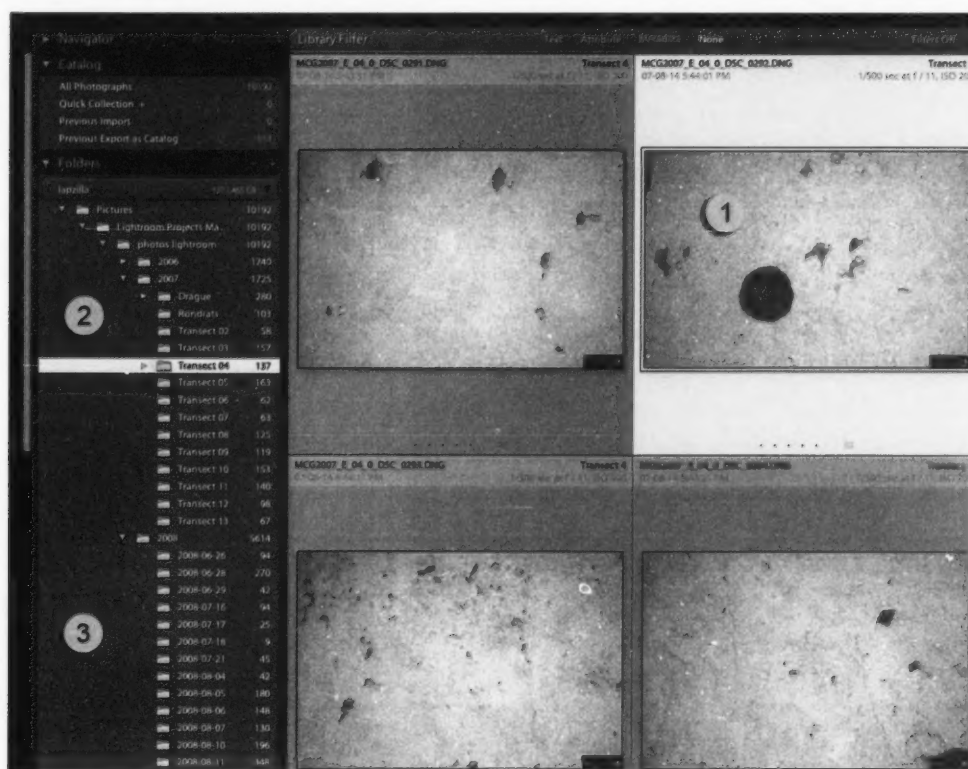
Figure 59. Examples of folder organization. (1) Underwater images (2) filed by year and transect. (3) Laboratory images filed as received, by year and date.

Field images (on-deck, at-sea)

Images taken while at sea were often less-than-ideal: images were usually blurred because of close-up focussing or camera shake. These were taken for casual interest, after the dedicated work of receiving and sorting specimens had been performed. Nonetheless, on several occasions, even a blurred shot of a captured specimen was sufficient to give a good idea of the species at a location (because of a camera's timestamp). While the images were "no good" from a quality perspective, these files became crucial as image data for confirming and correcting paper notes, especially when specimens were examined at sea but not kept for the laboratory (i.e., too much volume to conserve).

Laboratory images

Images taken when back in the lab benefit from better conditions (counter space, more lighting, no vibration), but as is the case with field images, it is not imperative that the images be at their aesthetic best to be useful for a project. In several instances, images were taken as a means of quickly documenting things such as frozen samples or specimens in a vial or a jar. When tagged with a keyword (i.e., collection) in an image catalog, these images served as valuable references to specimen lists, enabling confirmation (i.e., size, condition) before having to spend more time in the freezer or handling vials.

Image analysis

For biological work, an image catalog such as *Lightroom* proved itself useful for organizing and finding files based on their features, using tags stored in metadata fields. Most tags were also exportable, such as filename, GPS coordinates, keywords, and location were also exportable. However, there is a need to document other features in an image for underwater transect analysis, i.e., counts of organisms, and their x,y position on an image. In other studies, this may be accomplished using the *ImageJ* freeware; this is a counting program outside of *Lightroom*. For this exploratory project and under time constraints, it was deemed that the ease of viewing, sorting, and editing images (non-destructively) gave the advantage to using *Lightroom* and counting manually rather than counting with *ImageJ* externally. In an ideal situation, the strengths of these two tools would be more closely linked for providing quantitative information along with qualitative metadata.

Metadata

The use of filters and collections in *Lightroom* and other image catalog programs provided an efficient means to browse and organize the project images. The stage of tagging images depended on the data field. Filenames were copied into the title field; in case of future changes to the filename, the original name can easily be traced. The location field was filled using station name followed by GPS coordinates. Keywords were entered using a hierarchy: *mission*, with sublevels by mission; *biota,* with sublevels for *organism* or *tissue*; and *other,* with sublevels for other items (rock, gravel, etc.). All photos of a single mission receive that name in a batch. Organisms viewed in an image were tagged by its name or by the tissue if not alive (e.g., shell, worm tube). A single image could then be filtered by keywords for mission, the species shown, and other

information. Finally, additional metadata was inserted when available: comments in the caption/description field; copyright, creator, and e-mail for DFO region, photographer, and contact.

Collection and labels were also used for sorting and organizing the views in the image database, but this information is generally not available outside of the *Lightroom* catalog. Dynamic collections were automatically built using rules such as "all images with keyword for dredge 2007." Labels were applied to rank and group the types of images. For example, colour labels were used as alerts: yellow for uncertain identifications or turbid images, blue for stationary photos along a tow transect, red for transit photos (off of the sea floor) during a tow. Flags indicated images of particular interest, such as clear examples of a species, while stars were used to rate image quality such as best focus.
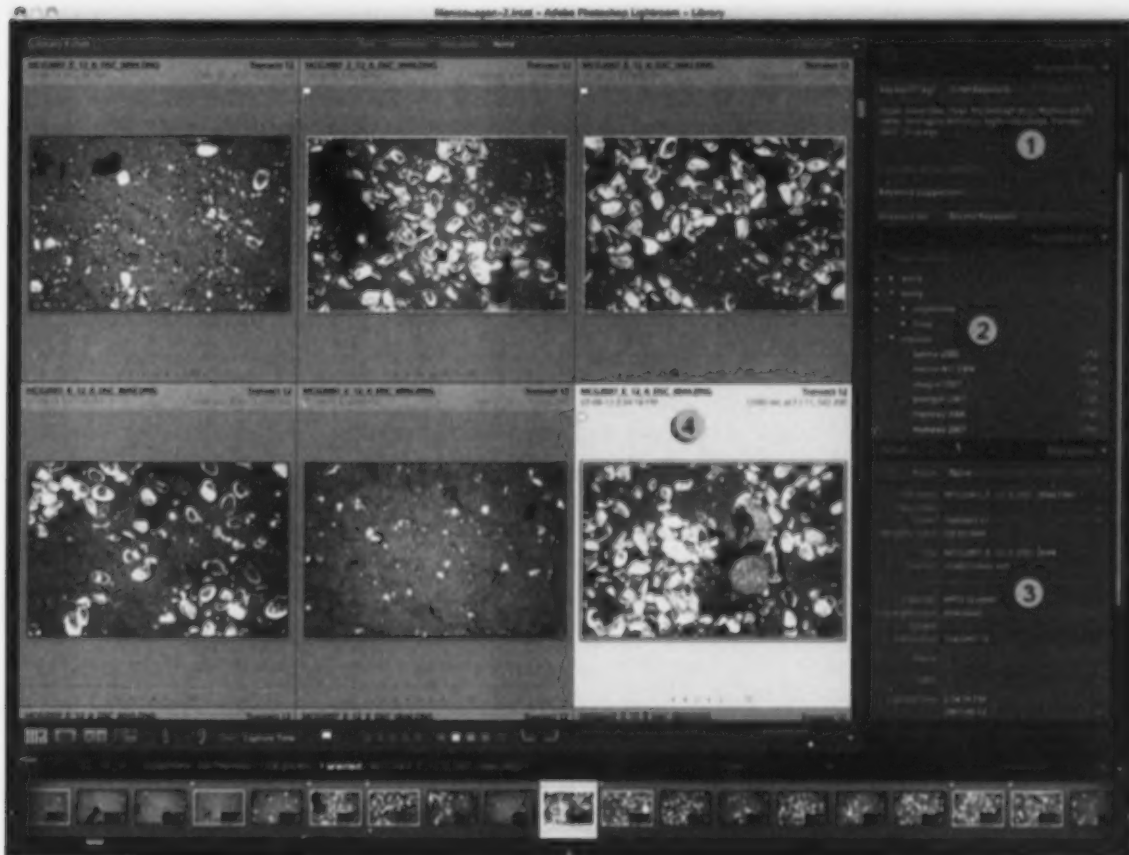
Figure 60. Metadata displayed in a *Lightroom* catalog. 1) Summary of keywords tagged to the selected image (light gray cell). 2) Hierarchy of keywords for ease of navigation in collapsible lists. 3) Summaries of other fields such as title, caption, and location. 4) Selected fields (image, location, date, camera settings) viewed as headers on thumbnails.
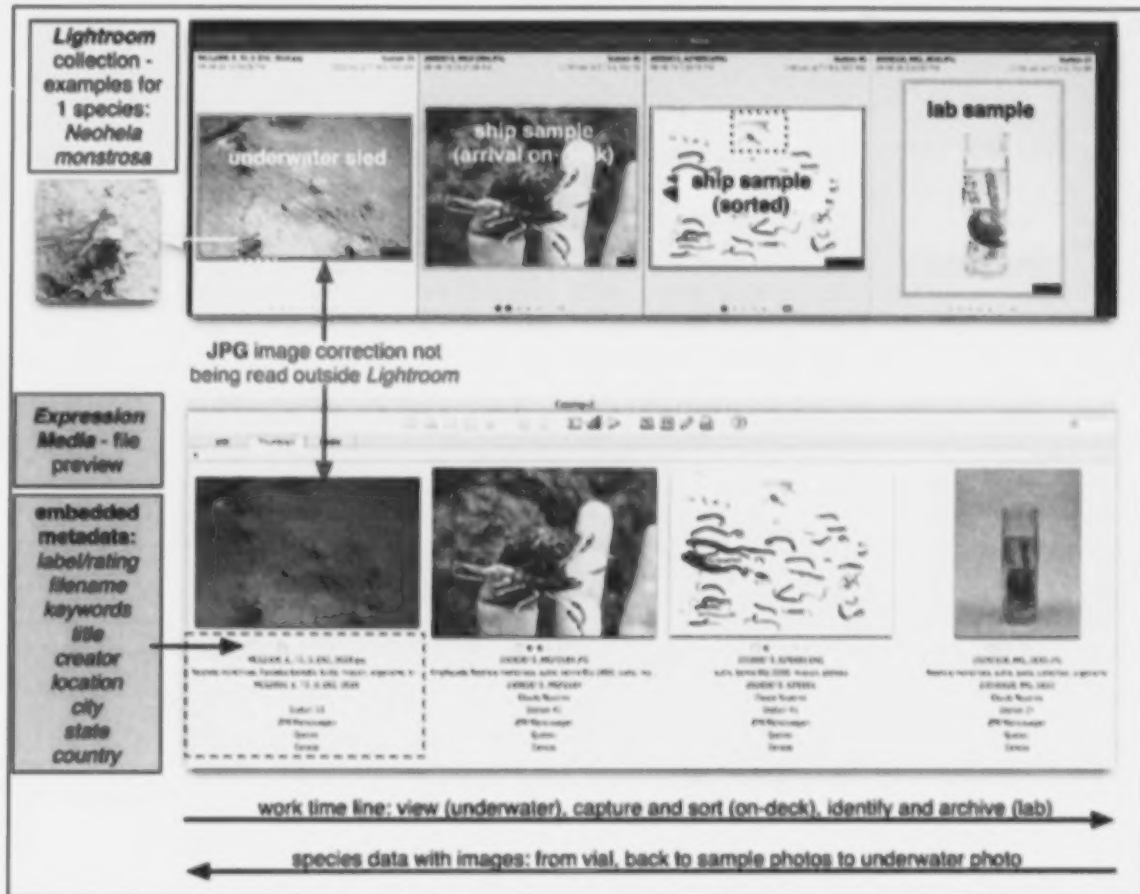
Figure 61. Image query for a species, found and displayed using the embedded metadata tags being read in and outside of the project catalog.

Figure 61 (**upper**) presents different image activities for one species in the *Lightroom* project. *Lightroom* metadata labels displayed above each image are for filename, date, location, and photo settings. Four example images are shown using *Expression Media* as an external file viewer (Fig. 61, **lower**). Previews confirm the presence of embedded metadata, although image thumbnails are not always shown correctly for images. In this case, instructions in XMP for image corrections to the JPG are stored in *Lightroom* but are not being read in the older *Expression Media* software. For the lighting corrections to be viewed, a new file copy could be saved from the original JPG. **Bottom arrows**: show the different kinds of image activities (underwater, on-ship, in lab) and their value as data in two ways: first, as chronological documentation, or "proof" that specimens were viewed or captured during a cruise (right arrow) and second, as a means to retroactively corroborate identifications, working backwards from positive identifications in the lab to original captures and views underwater from similar stations (left arrow).

5.8. Field: Protocol for cetacean photo-identification

Workflow summary

> *prepare cameras, clocks, and GPS*
>
> *shoot images for useful feature (fins, back)*
>
> *transfer files and rename with enough increments to be unique*
>
> *collect related data (mission code, location, weather, species, contact, etc.)*
>
> *compile image files and related data into a digital image catalog*

5.8.1. Images for photo-identification

Photo-identification of whales involves the collection of images showing a relevant feature that can then be compared with other examples. Images of characteristics of the whale and correctly referenced time and location data are thus required.

Camera preparation
- **synchronize time** on cameras or take a reference photo (e.g., of a clock or GPS unit)
- **begin logging** track if GPS is external (ship GPS, handheld GPS unit, or data logger)
- put camera **on standby** if GPS is internal (may drain battery, but position will be ready)
- use high shutter speeds and **ISO** (400 or greater)

Image data
- **focus** camera on features, i.e., dorsal fin and back, especially on scars and markings
- digital image files should be full-size JPG (at least 5 MP) or RAW
- scanned film (slides and negatives) should be JPG, 16-bit TIF, or RAW at full optical resolution, usually from 1200 to 4000 dpi, depending on scanner capabilities
- scanned prints (4 × 6 to 8 × 10) should be JPG or 8-bit TIF at 300 dpi

5.8.2. File renaming for photo-identification

Photo-identification catalogs often have very large numbers of files. Once files are transferred from the camera, their default names must be changed to be unique. There are many styles to renaming files. The solution is to compose a scheme with enough successive increments so no two files share the same name.

- document the file renaming scheme being used
- do not use accents, punctuation, or blank spaces (substitute underscore or hyphens)
- renaming is best done using a **batch editing tool** as found in image software
- run an initial test on a copy: some tools cannot undo (revert to original names)

Style example 1: Basic unique name
(Adding creator's name to distinguish files if multiple photographers on mission)
Prefix initials and date to default name = *NN_YYMMDD_XXXX*

NN =photographer initials, *YYMMDD* =year, month, day, *XXX* is original file number.

    original: *IMG_0187*.jpg

    renamed: *TN_100901_0187*.jpg (Trevor Newton, Sept 01, 2010)

Style example 2: General ship survey
(No overlap in timestamp is possible if only one camera was used on the mission)
Prefix mission code and full date stamp = *CCCC_YYYY-MM-DD_hhmmss*

    original: *IMG_0187*.jpg

    renamed: *TE06_2010-09-01_091224*.jpg

Style example 3: Single-species missions
Prefix species and mission code, replace original number with new, incremental number
and leading zeros = *SS_CCCC_XXXXX*

S = species initials, *C* = event/mission code, *XXXXX* = incremental numbers

    original: *IMG_0187*.jpg

    renamed   *Bp_TE06_00001*.jpg (finwhale, Teleost cruise 06, photo 1)

5.8.3. Geospatial data for photo-identification

Geospatial data from ship or handheld units may be embedded in image files. This optional practice may be useful for future work but is more difficult if corrections are needed or location data is imprecise (e.g., no GPS; general map reference used).

- conserve track information in associated files (i.e., GPX, CSV)
- adjust image file timestamps before synchronizing if correction is needed
- synchronize GPS track data to digital photos using photolinking software
- image files without timestamps (i.e., scanned files) can be manually geotagged
- document if and how if photos were geotagged manually (e.g., add keyword or note in caption)

5.8.4. Image catalog for photo-identification

Collected digital image files need to be organized and tagged in order to be searchable (queried). This may be done using a dedicated cetacean photo-identification database or commercial photo cataloguing software.

- organize folders using a simple hierarchy, e.g., StL Gulf Blue whales/2008/2008-09-08
- tag files with essential keywords, e.g., mission or event, station or location, species
- rate and label images (i.e., image quality)
- archive full-size image files, image catalog, and associated data (i.e., spatial data).

5.9. Field: aerial image surveys

Workflow summary

> *prepare cameras, clocks, GPS, and spatial references*
> *shoot images in succession (overlap if possible)*
> *transfer files and rename with enough increments to be unique*
> *collect location data (projection).*
> *collect related mission data (e.g., contact, mission, flight path, species)*
> *develop an image data catalog with a set list of keyword terms*
> *archive images and related data (image catalog and associated database)*

5.9.1. Images for aerial photo surveys

Aerial survey images often serve as inventories of species, such as cetaceans at the sea surface or pinnipeds on the ice. Specialized camera systems are most likely to be used that have no traditional controls; however, reference systems should be verified.

Camera preparation
- **synchronize time** on cameras or take a reference photo (e.g., of a clock or GPS unit)
- **begin logging** track if GPS is external (aircraft GPS, handheld GPS unit, or data logger)
- **document** field conditions (visibility, altitude)

Image data
- maximize the image resolution and colour breadth, especially for breeding seal surveys
- digital image files should be full-size TIF or RAW
- scanned film (slides and negatives) should be JPG, 16-bit TIF, or RAW at full optical resolution, usually from 1200 to 4000 dpi depending on scanner capabilities
- scanned prints (4 × 6 to 8 × 10) should be JPG or 8-bit TIF at 300 dpi
- oversize (>8 in) film and prints should be sent out to a scanning service house

5.9.2. File renaming for aerial images

Photo-survey catalogs often have very large numbers of files. Once files are transferred from the camera (e.g., IMG_0001 to IMG_9999), new names are needed.

6. IMAGE DATA SOFTWARE EXAMPLES

While operating systems like Windows and Mac OS X come equipped with image and video software (or are available as downloads), third-party software is recommended for editing and managing image data and metadata. Several software packages act as systems to perform nearly all the tasks of editing and managing image data within their environment. The utility of these main packages are often enhanced by external plugins and small software tools that read, edit, or convert files for different purposes. The following list represents some of the major and specialized imaging software for science work, followed by general workflows for selected tools.

Main image editors

Google Picasa 3 (free)
- lightweight image editing (non-destructive) and file organization

Adobe Photoshop Elements 9
- intermediate-level image editing (raster) and file organization

Adobe Photoshop CS5
- advanced image editing (raster, parametric)
- file organization and metadata editing (with included Bridge)

Adobe Lightroom 3
- advanced photo editing (parametric)
- advanced organization tools using catalogs

Phase One Capture One 6
- advanced photo editing (parametric)
- note: Phase One has released *Media Pro* (their version of *Expression Media*), which is being closely tied to cataloguing with *Capture One*

Main video editors

Adobe Premiere Elements 9
- moderate-level editing
- integration (metadata and organization) with *Photoshop Elements*

Adobe Premiere Pro CS5
- professional editing tool
- common metadata (XMP) in the CS family of software
- native import of HD and raw video file formats (intermediate not required)

Avid Media Composer
- professional editing tool
- near-lossless intermediate codec (DN×HD) freely available

Sony Vegas Pro 10
- professional editing tool
- usually requires installation of intermediate codecs, i.e., Lagarith

Metadata editors

Exiftool 8
- edit all object-level metadata, e.g., EXIF capture date, GPS
- command-line tool; serves as the base in several other programs seen here

GPSBabel 1.4
- convert and prepare GPS data files for use in other software
- tool serves as the base for image geotagging software

Geosetter 3.4
- free geospatial tool for tagging image files
- extensive metadata editing and synchronization tools

RoboGeo 5
- edit geospatial and timestamp capture metadata for image files
- many export options for geospatial data

DVMPro 5
- read capture date, timecode, and GPS data for DV, HDV, AVCHD video files (original metadata may get lost during video editing)
- preserve with "burn-in" (visual stamp) of data on a new video file
- export video metadata as text files or subtitles for use in other programs

jMetaWriter 2
- create and edit collection-level metadata for DFO Science
- easy to use tool for writing Marine Community Profile (MCP) of ISO 19115 metadata standard
- preparation of fields to enable cross-walking of tables with other scientific database metadata initiatives
- resulting metadata housed with Science's metadata repository, based on GeoNetwork's MEST, and supported in NCR at Integrated Science Data Management (ISDM)
- if appropriate, records may be made available via harvest to DFO Science's internet portal, GeoPortal, for public discovery
- access from DFO **intranet**: http://marbiod11/OSD_Web/FOSDI/FOSDI.shtml

Morpho 1.9
- metadata editor for ecological datasets
- based on EML (XML-based Ecological Metadata Language)
- easy to use Java tool to create data packages: metadata and datasets
- projects such as data packages can be hosted publicly or internally

Media collection managers

Adobe Bridge CS 5 (included with *Photoshop*) file browser
- not a cataloger (does not save to a database document)
- reads photo, graphics, and video formats, including BMP, MPG, GIF
- powerful image metadata editor (IPTC-XMP), including batch functions

Photo Mechanic 4.6
- image browser and workflow management tool
- capture, edit, and annotate image metadata

CatDV Pro 8
- video file management using catalogs
- QuickTime-based (needs installation on Windows)
- extensive access to video metadata
- enables import and export of video metadata
- can also manage image and other document files

Expression Media 2 (previously *iView MediaPro*; newly released in 2011 as *Media Pro*)
- image file management using catalogs
- can also manage many video and other document files
- currently outdated, but still widely used

AtomicView 1.5
- recent alternative to *Expression Media*
- desktop media cataloger; server version also available
- currently for Mac, with Windows version in beta

IDImager Pro 5
- popular alternative to *Expression Media* (Windows only)
- powerful cataloguing and metadata editing for images
- also performs non-destructive image editing

Canto Cumulus 8
- enterprise-level document management

Google Desktop Search
- fast file search alternative to *Windows Explorer* for a desktop PC
- not a cataloguing tool and not for remote volumes

CDFinder (Mac) / *CDWinder* (Windows)
- file archiving: catalogs local and offline media
- principally for documents and image files
- local and server catalogs
- comprehensive metadata searches, including geospatial information

Specialty processing tools

ImageIngester Pro (shareware)
- capture ingestion: actions performed during import of photo files
- add metadata, rename files, direct copies to a backup
- saves time and ensures quality (file check and backups) prior to editing

PhotoAcute (commercial)
- combines multishots to reduce noise and increase detail
- file enhancement beyond normal camera capabilities
- obtain higher quality still images from video frames

Photomatix Pro (commercial)
- combines multishots of different exposures for high dynamic range (HDR)
- superior processing and fine-scale options compared to general tools (i.e., Photoshop)

Helicon Focus (commercial)
- combining a sequence of images with different focus points into a composite for greater depth of field
- important for macro photos with details in 3-D relief (e.g., shells, crustaceans)

ZooPhytoImage (free)
- automated classification of plankton from image scans of samples in a dish
- makes use of inexpensive flatbed scanners for high-resolution image analysis

VideoLanClient (free)
- valuable for previewing original video files (reads many codecs/formats)
- useful for image analysis of individual frames (playback controls, snapshots)

HDVsplit (free)
- capture HDV video from tapes to .m2t containers on computer drive
- automatically splits stream into clips at breaks
- automatically renames files by date-time

MPEG Streamclip (free)
- conversion and lightweight editing (split/join clips) of mpeg video files
- may need QuickTime for mpeg-2 operations
- used to prepare mpeg files for import into main video editors

Handbrake (free)
- conversion of mpeg-2 video streams to mpeg-4 files (.mp4, .mkv, .m4v)
- relatively slow (intensive processing), but very high quality H.264 MP4
- preferred option for exporting to use as mobile multimedia, e.g., iPod

Avidemux2 (free)
- video file rewrapping: AVI files to MP4 container without recompression
- prepare files to be read in QuickTime-based catalogs (i.e., CatDV)

Cineform NeoScene and *NeoHD* (commercial)
- convert video files to a "lossless" intermediate file
- high-quality intermediates are important for intensive colour and video editing

Matrox VFW (free)
- free codecs to convert HD video to high quality intermediate for editing
- alternative to *Cineform*

Lagarith (free)
- open-source intermediate video codec, including alpha transparency for editing

6.1. Google Picasa 3

Free desktop software for Windows and Mac.
- all-in-one solution for graphics, photos, and some camera video clips
- basic discovery, viewing, editing, and exporting tools on a single PC
- some web album and geospatial support through Google services

Workflow:

    1) **import** images
    2) **organize** files in simple collections
    3) **edit** images and tag with keywords
    4) **export** to store, or to edit and tag with advanced tools

Import files
Picasa can import from one source or all connected sources. Examples:
- import from camera card reader on USB
- find all image files on the computer (discover hidden and missing files)
- find images from selected folders (relevant image files)

Note that import from folders can be set up to:
- watch always (updates whenever folder content is changed)
- scan folder contents once only
- do not include (files not relevant, such as graphics or parts of saved web pages)

Organize images
- make albums and drag files into these collections (does not move files on drive)
- moving folders in Picasa changes their location on the drive

Edit images
- automatically works on a copy; this is version editing (preserves original)
- limited controls for minor retouching and cropping
- limited metadata tagging: keyword, caption (title), geotagging

Export images
- collections cannot be shared between computers (for one user only)
- individual files and albums of files can be exported to archives/catalogs
- versions can be exported to the web (options include file resizing and maps)

Alternatives to *Picasa*:
    beginner to intermediate level: *Adobe Photoshop Elements 9*
    intermediate to advanced: *Adobe Lightroom 3*

6.2. Adobe Lightroom 3

Image editing desktop software for Windows and Mac.
- easier to use and less expensive than *Photoshop CS5*
- "parametric" image editing: works on previews, conserves original files
- used to ingest photo files, process images, edit annotations, export versions
- catalog file can be transferred between computers
- only one catalog can be open at a time (no multiple catalogs or network use)
- what's new in v.3: better noise processing and some importing of camera video

Workflow:

1) **prepare** camera and tools (clocks, GPS, lights)
2) **import** files from card reader; backup originals
3) **process** files (quickly organize and tag with minimal metadata)
4) **edit** (enter keyword tags and other metadata; perform image corrections)
5) **export** JPGs for image analysis (i.e., species counting) and image distribution
6) **archive**: convert RAW to DNG, backup catalog and full image files

Prepare camera
Lightroom users are presumably more advanced, with some prior planning being likely.
- camera settings (full-size JPG or RAW)
- camera clock: correct time and date and take a reference photo, i.e., a computer or GPS screen (timestamp can be corrected afterwards using time shown in photo)
- begin tracking with GPS or take a geotagged photo (i.e., smartphone)
- place external lights or reflectors/backgrounds, with a white label or colour card to be photographed in first photo (check white balance on-screen before continuing)

Import files
While files may be imported automatically wirelessly or when tethered to a computer, in most cases files are transferred from a camera or a memory card at the end of a shooting sequence.
- Insert camera card in a reader using USB, FW, or ExpressCard interfaces
- Options for importing will appear in a dialog box. Several options can be enabled at this stage or be done later. Note that certain options will slow the import but will save work later (such as converting DNG and creating full-size previews). For older computers or when pressed for time, it is best to do a simple file import.
- Copy files to a designated folder location (such as by date)
- Import using a metadata preset (if established, e.g., mission/contact, basic keyword)
- Rename files on import according to a preset (if established)
- Convert RAW files on import to DNG
- Create full-size previews of imports

Processing images: organize folders and edit metadata

Both photos and some video files (notably from HDSLR) may be viewed and organized in *Lightroom 3*; however, video support is very basic and best reserved for dedicated editors (see alternatives below).

- quickly review and tag images with ratings, labels, and flags:
    - star ratings for obviously good images
    - colour labels for image types (event, workstage, panorama, subject, etc.)
    - flags for rejects, regular, and remarkable images
- make collections (albums) for useful groupings by subject or date
- activate filters to check images for metadata status (keywords, GPS, location, title)
- add metadata to images: keywords, title, location
- geotag images (if information available) using plugins or external tools
- confirm metadata using filters and smart collections (albums with metadata rules)

Edit images

- correct white balance using dropper on a white target
- increase or decrease exposure, highlights, and shadows (fill light) if necessary
- crop, sharpen, and de-noise if necessary
- apply correction settings to all in a sequence

Advanced editing

- corrections for an image can be applied locally using Develop tools
- export to Photoshop or other editor for stitching compositions or layered corrections

Export images

- catalogs are intended to operate on a single desktop
- individual files and albums of files can be exported to archives/catalogs
- an empty catalog, or a catalog with originals, can be exported to another computer or an archive

Reference work for more information:
Krogh 2009. The DAM Book, second edition. O'Reilly Press.

Alternatives to *Lightroom 3*:
    image editor: *Adobe Photoshop Elements 9*
    expert image editor: *Adobe Photoshop CS5 with Bridge*
    image cataloger: *IdImager 5, Expression Media 2 (now Media Pro)*
    expert video editor: *Sony Vegas Pro 10, Adobe Premiere CS5*
    expert video cataloger: *CatDV Pro 8 Professional*

Tips for using Lightroom: external processing

Third-party metadata plugins
Adobe offers software developer kits to make use of the SQLite database that stands behind the graphical interface of *Lightroom*. Among developers, two sites in particular have produced a range of plugins to manipulate the metadata and the export options from *Lightroom* catalogs.

Photographer's Toolbox (shareware)
http://www.photographers-toolbox.com/
Examples of current tools:
- Exporting images (*FTP Publisher, TreeExporter* [preserves folder hierarchy])
- Image output (*LR/Mogrify*: visible marks, annotations, etc.)
- Managing metadata (*Keyword Master, Search Replace Transfer, Syncomatic, LR/Transporter*: import, modify, export metadata)

Jeffrey's Lightroom Goodies (donation)
http://regex.info/blog/lightroom-goodies
Examples of current tools:
- Exporting images (publish to popular sites, e.g., PicasaWeb, Flickr)
- Exporting data (*Metadata Wrangler, Run any command, Snapshot on Export*)
- Geoencoding (*GPS Support, GPS Proximity Search*)
- Utilities (several data filtering tools)

Third-party image processing tools
Editing for multiple images or layers is not possible within *Lightroom*. In these situations, files may be exported from within *Lightroom* to undergo processing in a compatible tool before being re-imported as a new file. Examples of external processing include

Photoshop
- editing layers or producing panoramas (merge multiple shots)

Photomatix Pro
- merging multiple shots for high dynamic range
- dedicated plugin is available

Helicon Focus
- merging multiple shots for large dynamic range (see Section 6.8)

6.3. Adobe Photoshop CS5

Image editing desktop software for Windows and Mac.
- traditional tool, important for heavy image processing using layers.
- does not edit images automatically with versions; originals must be conserved
- used to make compositions, e.g., panorama and mosaic stitching
- includes *Adobe Bridge*, a file browser/metadata editor (**not** a cataloger)
- what's new in CS5: better retouch, mosaic-stitching, processing, and browsing.

Workflow:

1) **edit JPG files** and save as a **copy** with **new** filename
2) **edit RAW** images and save as **DNG** (non-destructive, so no filename change)
3) **export compositions** as flat 8-bit TIF with LZW compression and **new** name
4) enter **keyword** tags and other IPTC-XMP metadata using **Adobe Bridge**
5) **archive** into a cataloguing program

Image Editing
- resaving a JPG will lose some quality, so save as a copy and conserve original
- save copy with a new filename (e.g., -edit.jpg, -copy.jpg, -v2.jpg)
- using layers (in TIF, PSD) will help to conserve work edits, but increases file sizes
- flatten multi-layer composition files (HDR, panoramas, focus stacks) and save as TIF
- edited RAW files are saved as DNG, conserving the RAW image data along with a
  preview and the metadata from XMP into one file

Metadata Tagging
- keywords and other IPTC-XMP can be entered using the Bridge file browser
- indicator metadata such as ratings and colour labels are conserved for files read by
  Adobe programs (*Lightroom, Elements, Premiere*), but not always in other software
- optional: when exporting files to external collections, embed the ratings as keywords
  (e.g., 1star, 2star)

Reference work for more information:
Krogh 2009. The DAM Book, second edition. O'Reilly Press.

Alternatives to *Photoshop CS5*:
  parametric image editor: *Lightroom 3, CaptureOne 6* (browser, not cataloger)
  image cataloger and lightweight editor: *Photoshop Elements 9, IdImager 5*
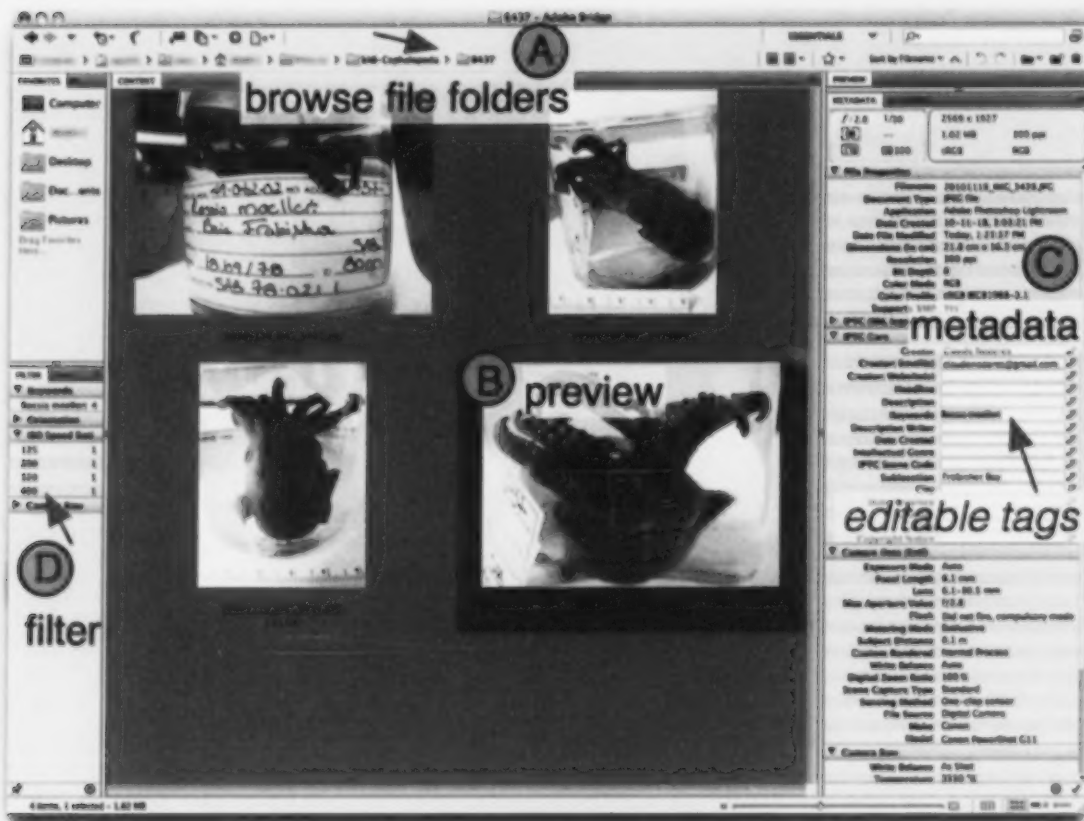
Figure 62. *Adobe Bridge CS5* as an file manager for images and metadata.

In Fig. 62, the *Bridge* application serves to browse (A) folder contents for image, graphic, and video files. Previews are displayed (B) as are file metadata (C). IPTC and XMP fields may be edited to embed object-level metadata, which serves as filters (D) to help find groups of files. Files may be moved or saved into collections, but the *Bridge* view cannot be saved as a permanent catalog database or transferred between computers. Instead, the edited metadata of individual files will be read when viewed by other browsers or catalogs.

6.4. Expression Media 2 (Media Pro)

Photo cataloguing desktop software for Windows and Mac. Began as *iView MediaPro* then became *Microsoft Expression Media*; released in 2011 as *Phase One Media Pro*.
- organization of thousands of files on attached volumes (but not for network use)
- emphasis on images, but also reads many graphic, document, and video files
- actions to bulk-convert files into other formats and to export metadata as text
- up to 128,000 files or 2 GB catalog size (limits lifted in the new *Media Pro*)

Workflow:

1) **import** folders to view content and be cataloged
2) **organize** files: move folders, **rename** files
3) enter **keywords, ratings,** and other metadata in IPTC fields
4) create **collections** (virtual sets)

Import
- used to discover all files nested in folders on a volume (drive, DVD, card, etc.)

Organize
- move folders from **within** the program (**not** with *Windows Explorer* - will lose file links)
- rename files according to a defined style (note: renaming cannot be undone)

Keywords, ratings, and other metadata
- alphabetical lists of keywords (can import a controlled list)
- hierarchical lists are possible but not always understood in other software—caution!
- long, flat lists are easiest to use and manage (no future conflicts or lost work)
- other IPTC fields can be filled (title, caption, places, contact), but most are not needed
- rating files with stars and colour labels are useful for filtering by quality or subject
- ratings data may be lost in other software (use keywords, e.g., "1star," "2star")
- older legacy files like BMP or AVI do not embed metadata; data is kept in catalog

Collections
- automatically makes sets based on capture date, camera type, file type
- can create album collections (catalog sets), i.e., for projects across dates
- catalog sets are part of the software; data about sets cannot be exported

Reference work for more information:
Krogh 2009. The DAM Book, second edition. O'Reilly Press.

Alternatives to *Expression Media/Media Pro*:
Current catalogers with personal and server versions: *IdImager, AtomicView, ACDSee*
File browsers: *Google Picasa, Adobe Bridge, Adobe Photoshop Elements*

current filter (by a keyword)

flat list of keywords
(species and others)

selection of fields shown:
  rating
  filename
  title (e.g., cruise no.)
  keywords

also (older IPTC):
  category (group)
  intellectual genre (type)

files and folder
locations (active
and offline drives)

fields available
for organizing
and filtering

final composition:
depth of field and
mosaic merged files
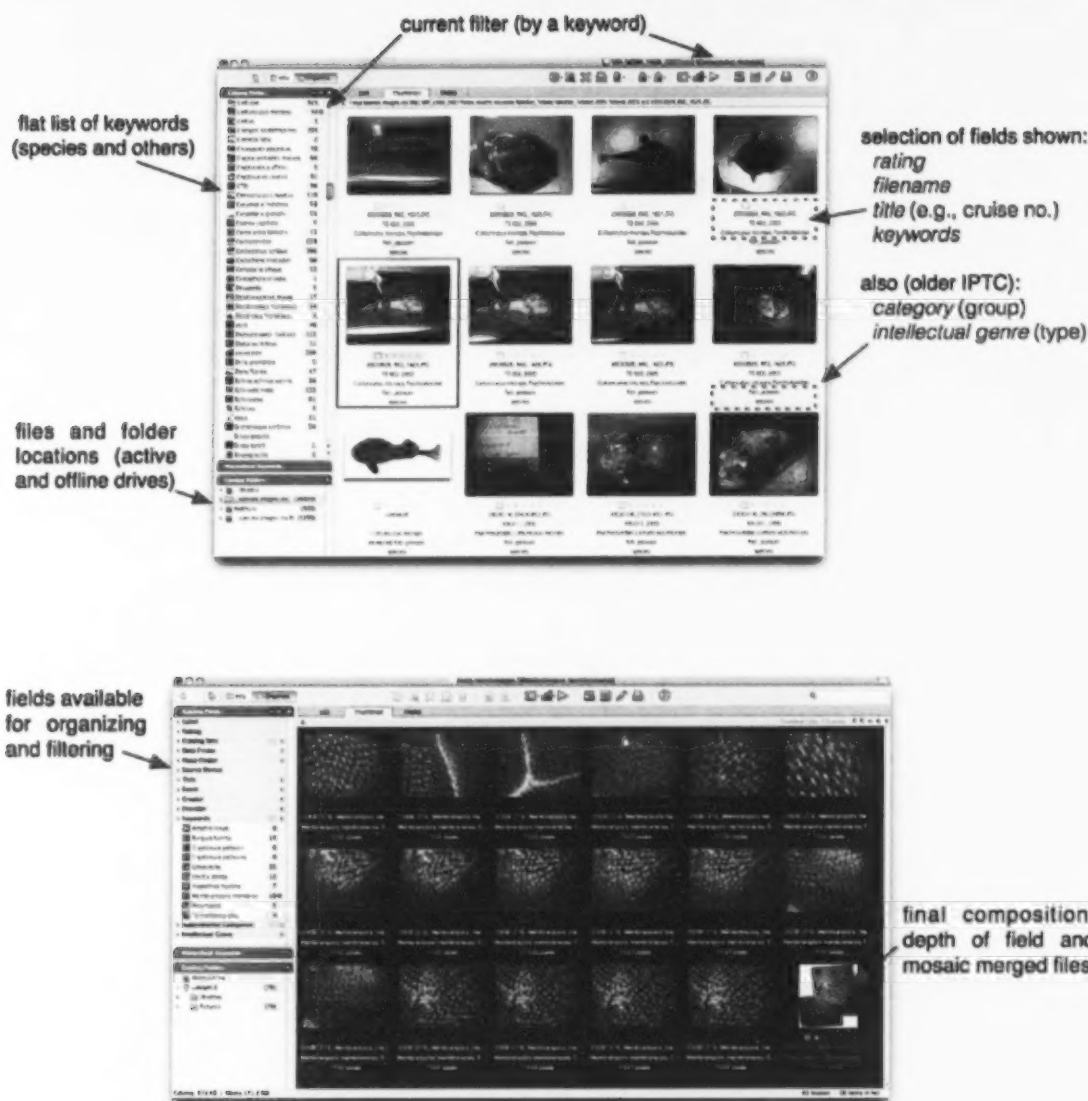
Figure 63. Example of a permanent (top) or a temporary (bottom) catalog.

In a **permanent** catalog (Fig. 63, top), several metadata fields will be filled out to assist in future searches for an image file across drives, even when offline.

In a **temporary** work catalog (Fig. 63, bottom), the catalog browses, tags, and organizes images briefly (not saved), in this example by helping to select microscope images to make stacks for depth of field and mosaics (photostitching).

A temporary catalog is also extremely useful for performing **bulk actions**, for example, **converting** a folder of hundreds of TIFF files to JPEG, or **exporting** image metadata from a folder of image files for use in *Excel* or a database program.

Once the action has been performed, the "catalog" is discarded. In this sense, the catalog is being used functionally as a **file browser**. The advantage with using *Expression Media* instead of a browser is 1) the high speed of browsing and 2) the availability of **bulk actions** (converting files, exporting metadata) that are as to easy to perform on one as on a thousand files. In addition, the longstanding popularity in the past for *iView Media/Expression Media* (Krogh et al. 2009) has led to the development of data export scripts. This is similar to the development of data editing plugins for *Lightroom*. By comparison, *Photoshop* arguably has more scripts for image editing instead of data management.

Unfortunately, the power of the available actions may not be obvious when presented as menu bar options in *Expression Media*. In Fig. 64, the five most useful and powerful actions available for bulk tasks are: 1) synchronizing the changed metadata in the catalog to the image file (IPTC-XMP fields), 2) clearing annotations (for example, to strip off in bulk all private information), 3) batch renaming (clearing and giving names to files according to your needs), 4) converting image files (in file **type**, file **size** [pixel dimensions], and **quality** if JPG), and 5) extracting metadata as text for subsequent use in a worksheet or a database.
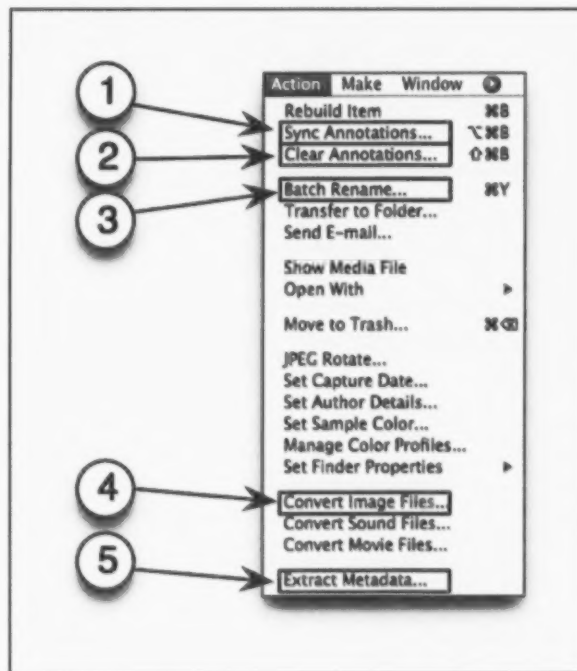
Figure 64. Top five bulk actions from the menu bar in *Expression Media*.

6.5. RoboGeo 5

Easy to use image metadata editor for GPS and timestamp EXIF fields
- comprehensive tool to add, correct, and export geospatial metadata
- plugins are available to perform similar tasks within image software

<u>Workflow</u>:

1) **examine** image file timestamps
2) **import** geospatial information
3) write to EXIF headers
4) export data to maps, Google Earth, or as text files

Examine files
- automatic geotagging is based on correct time and date in image files
- if a reference is known for correction, then the offset is applied and written to EXIF
- corrections may need to account for UTC time zone and daylight saving time

Import information
- GPS tracks (.gpx) are imported and synchronized with images by date/time
- waypoints and geotagged reference photos may also be used manually to tag non-geotagged photos from the same location
- **reverse geocoding** (known location) writes coordinates manually using Google Earth, maps, IPTC location names, or entered coordinates (no GPS required)

Import information
- geotagged images will have GPS coordinates written into EXIF fields
- need to "refresh" (update, read, or sync metadata) files for updated information to appear in image catalogs, i.e., *Lightroom, Expression Media*

Export data
- geotagged images can be exported onto maps: Google Maps, Bing Maps, Google Earth KML or KMZ, or shapefiles
- data can be exported as text, such as .csv or .gpx for use in an *Excel* worksheet or a database (*Access, Oracle*, etc.).

6.6. DVMP Pro 5

Unique tool for editing standard (DV) and high definition (HD) video metadata
- also a media player, DV video capture tool, and metadata display tool
- comprehensive functions for HD (AVCHD, HDV, HDD) video files
- principally used to stamp time and geospatial information on HDV/AVCHD videos because this metadata is typically stripped when converting to intermediate codecs for editing

Workflow:

1) **capture video**
2) **convert** and burn-in metadata
3) **export** metadata files

Capture video
- capture DV from tape
- use *HDVSplit* software to capture from HDV tape, rename clips by capture date-time, then open with *DVMP Pro* (Fig. 65)
- read AVCHD files directly (transfer from memory cards/drive)
- if necessary, correct or adjust timecode, date, and time of captured video

Convert and burn-in
- visual burn-in of the video time, capture date, and time is an analogue means of preserving this metadata for subsequent visual analysis
- some Sony and Panasonic AVCHD cameras can record geospatial data, which can then be read and displayed using the burn-in
- for HD video streams, the burn-in is performed when converting to a WMV or AVI container file, for subsequent viewing or editing in *Vegas*, *Premiere*, etc.
- converting to WMV always uses Microsoft's native VC-1 codec
- converting to AVI may use any one of a number of installed free or commercial video codecs (see *DVMP* documentation for recommendations), including uncompressed video, MJPEG, MPEG-2, and MPEG-4
- choice of codecs may be selected for processing speed (e.g., Divx mpeg-4) or quality (e.g., Lagarith lossless)

Export metadata
- capture information (time, date, camera settings) may be exported as text files to preserve original video metadata and import into databases
- subtitles can be exported from video files, i.e., tagged transcriptions or timecode when encoded as data (not burn-in) by *DVMP Pro* or *CatDV Pro*
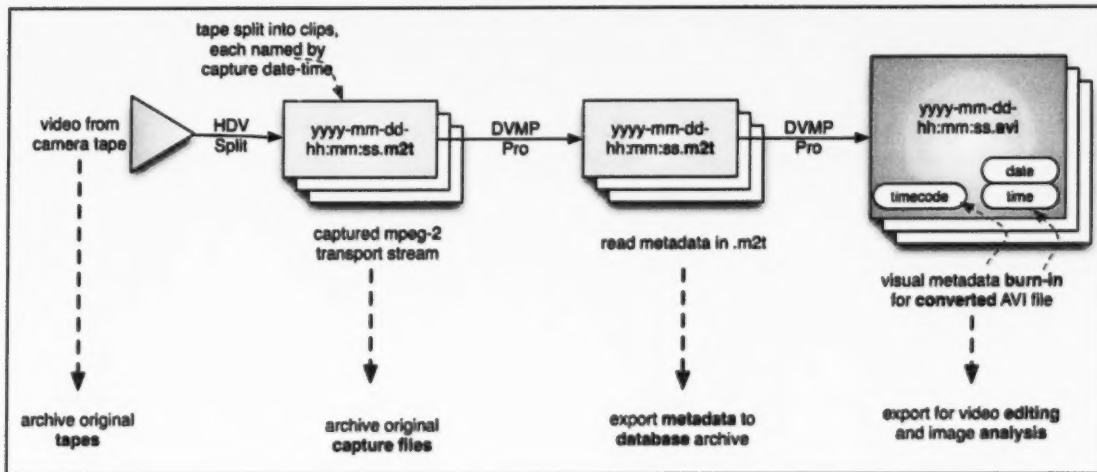
Figure 65. Schema of a video metadata workflow. Video from tape is captured as renamed clips using *HDVSplit* then converted to .avi container files with visual burn-in of metadata using *DVMP Pro*.
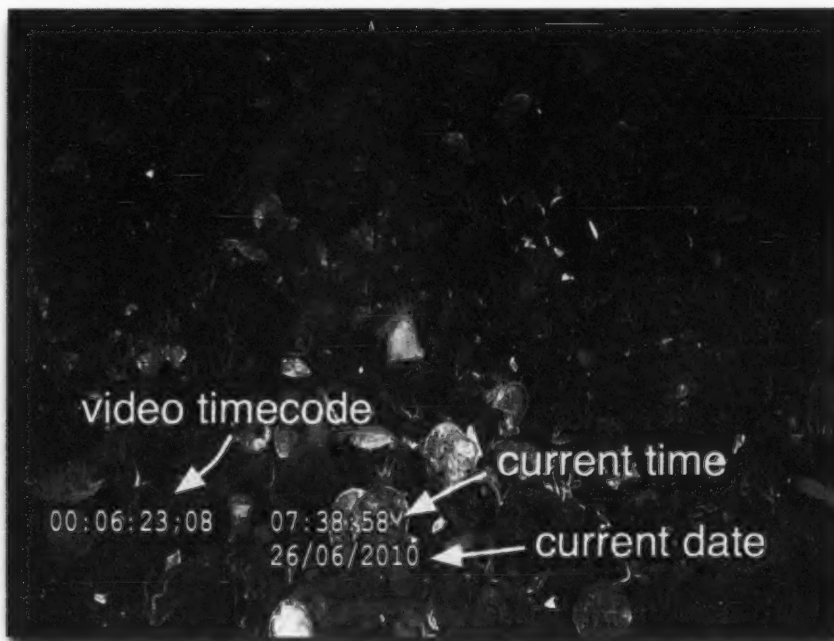
Figure 66. Screenshot of a visual burn-in to video file of capture metadata.

6.7. CatDV Pro 8

Cataloguing desktop software on Windows and Mac
• Standard, Professional (single PCs), and Server (shared catalogs on PCs) versions
• for organizing and cataloguing thousands of files on attached or remote volumes
• emphasis on video clips, but also reads images and document files
• relies on installation of free QuickTime 7 plugin (not with Windows by default)

Workflow:

1) **import** folders to view content and be cataloged
2) **convert** files to be read by catalog
3) **organize** files
4) view **metadata** and edit with notes
5) **export** tagged files and catalogs

Import folders
• enables discovery of clips
• brings to light potential issues (formats, missing metadata such as timestamps)

Convert files
AVI files may need to be **rewrapped** to QuickTime (same content, new format container)
• .mov container enables thumbnail previews and extended metadata editing, including geospatial information

Organize files
• move folders
• rename files, if not already done at an earlier stage, (e.g., capture)

Edit metadata
• view technical metadata
• edit by adding content notes to facilitate searches
• Verbatim Logger tool places transcriptions at scenes in a clip
• can export times and transcriptions for importing into a database

Export files
• convert metadata-tagged files as H.264 clips to media collections
• export catalogs for browsing and searching by workgroup members

Alternatives to *CatDV Pro*:
Some functionality for organizing video clips and metadata in *Expression Media, Photoshop Premiere Elements 9 (Media Organizer), and Adobe CS5 (Bridge CS5)*

Figure 67. Use of the video cataloger *CatDV Pro*. Above: an underwater clip displayed with metadata; below: example showing embedded geospatial information.
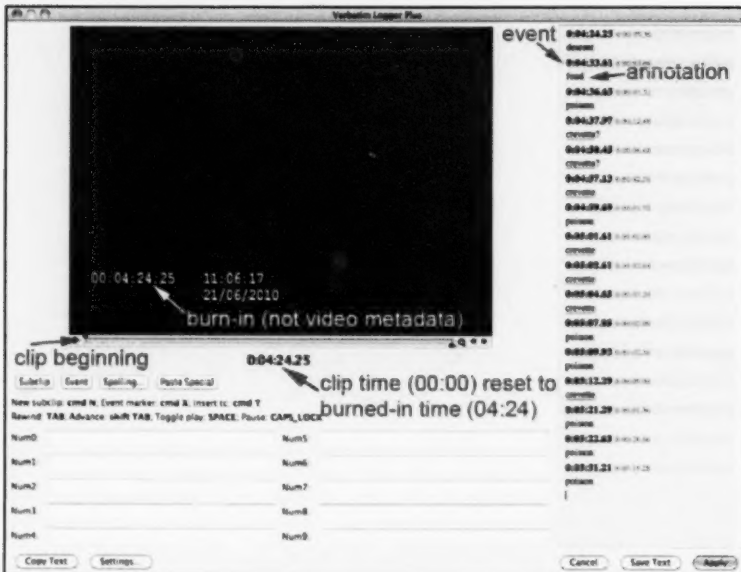
Figure 68. Use of the Verbatim Logger tool in *CatDV Pro* to mark video clips by events (time marker) and annotations (free-text).

The logged notes can later be exported from the video catalog as .csv text for use in *Excel* or a database. In the example shown, the start of the clip was reset to the videotape burned-in time.

6.8. Helicon Focus

Produce composite images with extended depth of field from a sequence of images (see example in Section 5.3: Digital Microscopy).

<u>**Workflow**</u>:

1) **set up** specimen
2) photograph at **different** focus planes
3) **combine** sequence
4) **retouch** and **export**
5) **organize** file group

Set up specimen
- select an area of interest to focus above and below
- decide the focus direction to be taken (up or down, or laterally)
- use a camera stand or mini-tripod to hold camera in same place during the shots

Photograph
- take successive images at different focus points
- small differences in images are preferred (no large gaps)

Combine sequence
- load focus image series into *Helicon Focus* and run alignment and processing

Retouch and export
- if necessary, retouch merge errors in *Helicon Focus* (or external editor)
- export as 8-bit compressed TIF or high-quality JPG

Organize
- use catalog software to group focus images along with final composite image (colour labels are visual aids to quickly select and process)
- tag images by keywords to designate purpose/technique, e.g., "focus elements" (images serving the process), "focus composition" (resulting product)

Reference work for more information:
Gulbins and Gulbins 2009.

Alternatives to *Helicon Focus*:
Limited or manual operation using *PhotoAcute* or *Photoshop CS5*
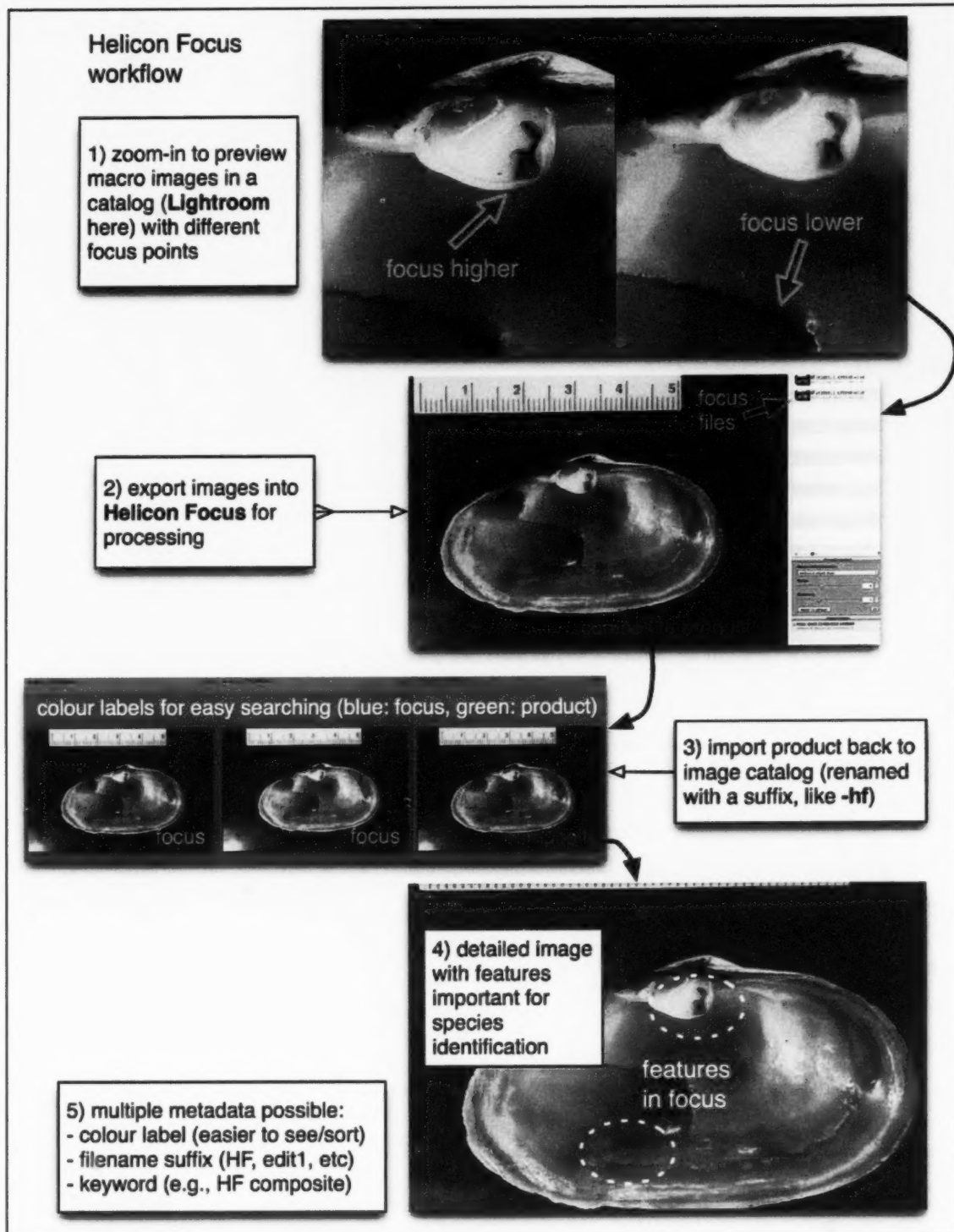
Figure 69. Workflow example using *Lightroom* and *Helicon Focus* to combine images for greater depth of field.

6.9. VideoLanClient

Open-source alternative to *Windows Media Player* (on XP) and *QuickTime Player* (on OS X); reads many video formats and has a range of custom controls. A screenshot tool grabs videos frames as PNG images (Fig. 69).

<u>Workflow</u>:

1) **set up** video
2) **view video**
3) **take snapshots**
4) **collect** files

Set up video file
- many file formats may be read without needing to install codecs, but some raw streams may need to be captured or rewrapped into a container
- choose options for displaying controls for video (speed, direction, etc.)

Take snapshots
- items of interest can be captured on-screen using the button or menu item
- screenshots are saved as full video-frame, lossless PNG and named by date of creation, i.e., date of screenshot, not the timecode of the videoframe.
- rename snapshots with a batch tool (*Expression Media* or others) in order to be traced back to original video clip

Collect files
- collect video clips, video snapshots, and related data (e.g., annotations in *Excel*)

Figure 70. Video snapshot (left) and clip (right) properties as seen in a temporary *Expression Media* catalog.

7. PUBLISHING IMAGE DATA

Image data may be easier to cite when it is part of a published work, such as figures in a document or as sets hosted on public science websites. Four examples of DFO experimentation with publishing image data are presented chronologically here.

7.1. Examples of DFO publications with image data

Case 1: *Marine species identification guide for the St. Lawrence.* 2003. C. Nozères, M. Berubé, V. Haeberle, R. Miller, F. Proust. CD-ROM produced by MLI, DFO-Quebec Region, Mont-Joli, QC. ISBN 0662672143.

The CD-ROM contained a PDF with links to species profile pages, including photos, a map, and notes (Fig. 70A). The guide was made using digital photography and software tools. Digital cameras (1 MP basic compact and 5 MP advanced compact) were used to take JPG images, including close-up macro shots. Organization of keyword-tagged files was done an *iView MediaPro* (original iteration of *Expression Media*) catalog which in turn enabled the lookup and selection of images. Editing of the images was done using *Photoshop*, while the page layout was completed in *InDesign* to produce French and English version PDFs.
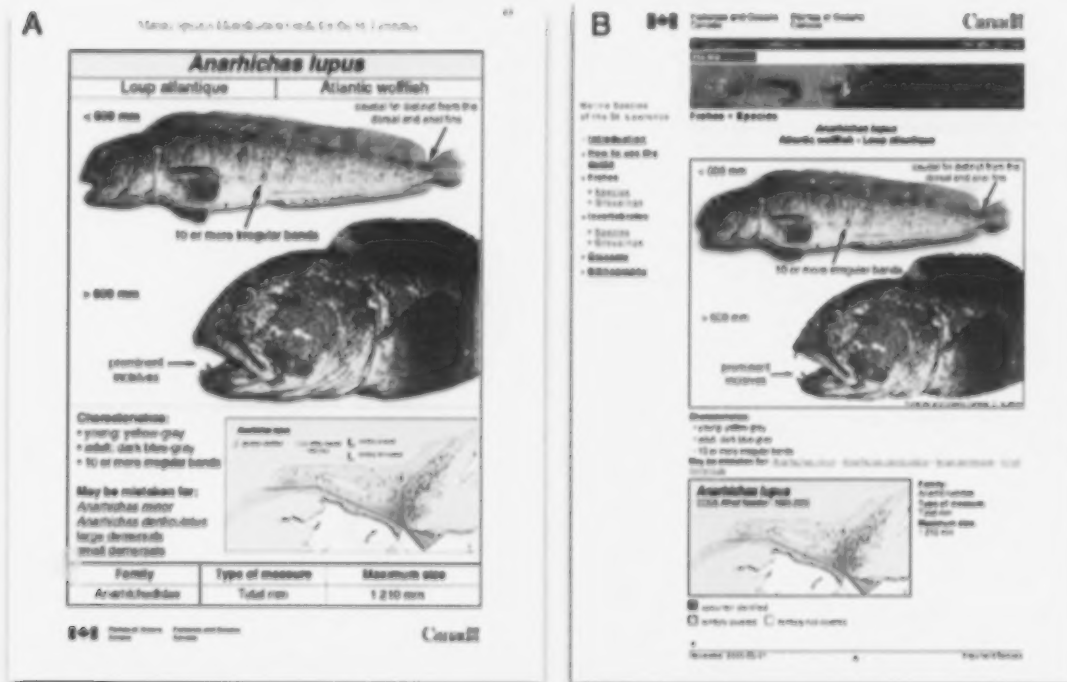
Figure 71. Publishing images as a special document. (A) Page from a digital photoguide. B) Document page converted as a webpage for OSL.

The photographs came principally from an August 2002 cruise, and the CD-ROM was released in spring of the following year (2003). The rapid turnaround and high quality would not have been possible using film photography and default tools such as *Windows Explorer, Microsoft Photo Editor,* and *Microsoft Word.* The dedicated photography on the 2002 cruise ensured quality images rather than copying low-resolution photos from the web as is common. Communications (Quebec Region) currently hosts the survey images using network image cataloguing software (*Canto Cumulus*) and a basic set of metadata tags.

The CD-ROM was a one-time only, special production. Back in 2003, it was not practical to download large (30 MB PDF) files using phone modems, and no suitable web site was available for DFO-Quebec to host image data. The solution was to distribute the PDF on CDs. In 2004, a web portal was launched in DFO-Quebec (osl.gc.ca, now slgo.ca; see section 7.2). The photoguide was converted into a website (Fig. 70B). The site's production was designed for government webpage standards and not for viewing large pages of images. The species website remained popular for several years. As of 2011, different websites of species images and image cataloguing initiatives are in development.

Case 2: *A rapid reference guide for the identification and sampling at-sea of marine fishes captured during commercial fishing activities.* 2006. Canadian Manuscript Report of Fisheries and Aquatic sciences 2744. D. Daigle, C. Nozères, and H. Benoît. DFO-Gulf Region, Moncton, NB.

Several regions and workgroups have produced photoguides as internal documents for their purposes. To meet a regional need for identifying species on cruises, Gulf Region was inspired to quickly produce a short guide of common species and sampling procedures, which was published as a report. Since then, other groups have also published reports with images and guides.
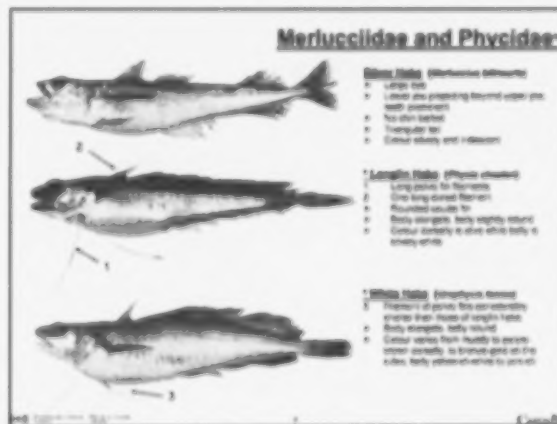
Figure 72. Sample page from a species photoguide in Gulf Region.

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Case 3: *Poisson connus et méconnus des fond marins du Saint-Laurent.* 2009. Le naturaliste canadien 133: 70-82. J.-D. Dutil, C. Nozères, P.-M. Scallon-Chouinard, L. Van Guelpen, D. Bernier, S. Proulx, R. Miller, C. Savenkoff (in French).

Discussions of species benefit from the use of images. Printing colour plates is costly. This article was printed in a monochrome paper journal, but the PDF version is in colour and large-size images are available as downloads as supplementary material at the journal's website. Cataloguing and image tools were used to locate and edit the keyword-tagged images during the manuscript review.
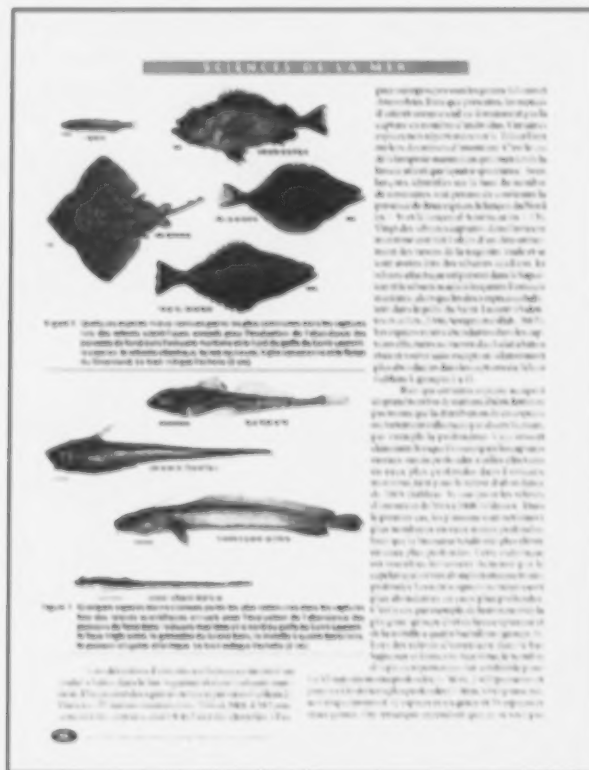
Figure 73. Sample page from a journal article with photos displayed in colour in the electronic (PDF) version.

Case 4: *Identification guide for marine fishes of the estuary and northern Gulf of St. Lawrence and sampling protocols used during trawl surveys between 2004 and 2008.* 2010. Canadian Technical Report of Fisheries and Aquatic Sciences 2866. C. Nozeres, D. Archambault, P.-M. Chouinard, J. Gauthier, R. Miller, E. Parent, P. Schwab, L. Savard, J.-D. Dutil. MLI, DFO-Quebec Region, Mont-Joli, QC.

The various DFO report series are intended for text and tabular data, with style guidelines less suited for presenting images. In the first two examples, this limitation was overcome by doing a special electronic publication and a short manuscript report.

In the present case, the photoguide had a typical origin—as an internal document produced by volunteers for use in regional surveys. *Photoshop* and *Lightroom* were used to produce the images, cataloged using *Expression Media*. In order to save time, Mac-only tools were used to manage and produce the bilingual graphic document. In order to make it available to a wider public, the Technical Report approach was chosen to present the text, tables, and maps in the form of a 75-page document summarizing work operations. The photoguide was then incorporated into this document as an appendix with 167 pages providing species photopages and illustrations (Fig. 73). As an appendix, the page layout was not restricted to the style guidelines as would be required in the main body of the report. Since the end product held a large number of high-quality images, the paper version of the report was distributed along with the electronic version as 90 MB PDF burned on a DVD (blank DVDs are less expensive than CDs because of Canadian music industry levies). The PDF may also be downloaded from the DFO library website. Many of of the original images by the lead author were are posted on science websites such as CaRMS, ROSM, and SLGO (see examples in Section 7.3).
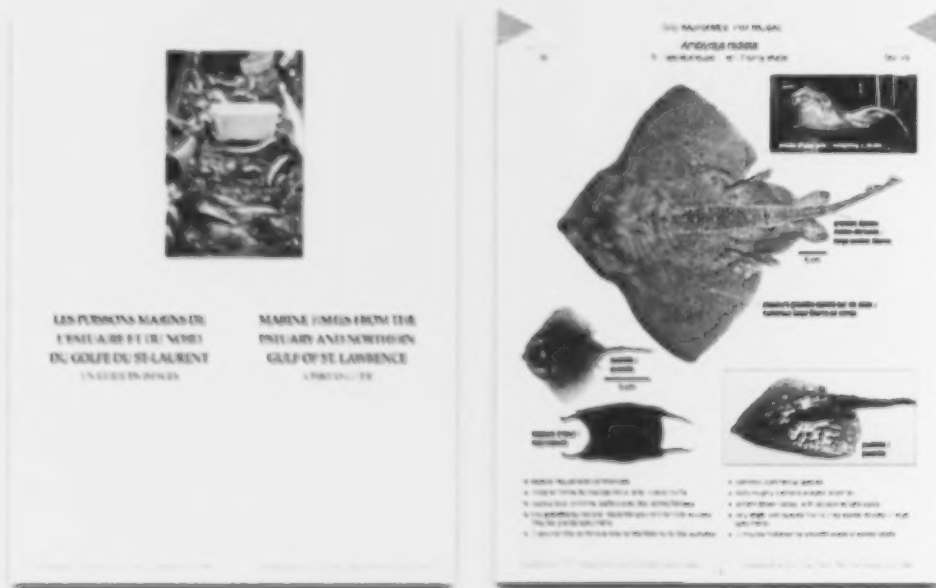
Figure 74. Publishing high-quality image data as an appendix in a report.

7.2. Examples of online image data projects

A number of science-oriented websites host photo galleries. Such sites demonstrate how image metadata may be displayed, and how web tools may be used to link to species references and generate maps. In some cases, the sites and tools are custom-built, while in others sites make use of existing third-party kits and tools, such as ePrints to catalog network images or the Google Maps API to generate map views.

Among scientific agencies, some image galleries may be restricted to viewing only, with contributions and corrections being managed exclusively by an administrator. Such sites may be standardized in their metadata and appearance, but by doing so may suffer from a lack of content. At the other end of the spectrum, web galleries hosted by groups often encourage contributions and editing by their users, including discussions (comments) on image entries. These user-led sites may host a great deal of content, but require moderation by editors to maintain standards in metadata. Examples of these photo gallery sites are presented in the list below.

Several image banks accept public submissions of images. Data for the image is entered on provided templates, such as an *Excel* worksheet (e.g., Morphbank, Barcode of Life), or a webpage entry form (e.g., ROSM, CaRMS/WoRMS[*]). In the case of WoRMS, a number of fields are available to provide information on the image (Kennedy et al. 2011). These fields are available for search queries by the community on WoRMS, its partner web portals such as EOL, and search engines like Google.

7.2.1. Image sites for viewing only

Library of Images from the Environment
http://life.nbii.gov/dml/home.do
Species images from USGS NBII
- image collections
- image filters (search tools)
- extensive use of image metadata: subject, creator, geospatial
- use of third-party web apps: taxonomy and maps
- options to "review" (bookmark) and download images
- downloaded images retain their EXIF, IPTC-XMP metadata

USGS Multimedia Gallery – photography, video, audio
http://gallery.usgs.gov/
Online images and video collections
- RSS feeds to follow updates
- organized by collections and metadata tags
- offers downloads of media in multiple sizes and formats

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[*] CaRMS (Canadian Register of Marine Species) is a regional node of WoRMS (World Register of Marine Species), with its own website hosting a subset of WoRMS content.

MODIS Image Gallery
http://modis.gsfc.nasa.gov/gallery/index.php
Topical satellite images from NASA MODIS
- web gallery searchable by region and satellite
- shows metadata and full caption (image description)
- offers downloads at several resolutions
- posts images of recent events (e.g., storms, plankton blooms)

ImageGeo
http://ogsl.ca/en/imageo/images.html (in French and English)
Marine-oriented geo-referenced photo gallery
- field operation photos with metadata
- image and metadata entry by administrator
- custom DFO initiative to be released as open-source software

SLGO Species Guide (*OGSL* in French)
http://slgo.ca/app-guidesp/en/index.html
Marine species guide with images, notes, and maps
- current public version (5/2011) is a viewing-only website based on a PDF from 2003 (see Fig. 70, Section 7.1)
- in development to host individual images and notes on identification and captures, including new maps
- new version may offer option for user-added content

SERPENT Project - deep-sea research using ROVs
http://www.serpentproject.com/
Dive project media catalog (photos and video clips)
- searchable, using open-source document archive software (ePrints)
- small previews only

HabCam - Habitat Mapping Camera System
http://habcam.whoi.edu/
Photo galleries from fisheries survey benthic imaging
- innovative imaging techniques (cameras, mosaic photos)
- associated data can be viewed (i.e., cruise information and tracks)

NEPTUNE Canada SeaTube
http://www.neptunecanada.ca/
Oceans science applications including underwater data and media browser
- archived and direct (live) remote imagery
- Flickr photogallery

Smithsonian Image Library
http://invertebrates.si.edu/
Museum collection records, with illustrations and images when available

Biodiversity Heritage Library
http://www.biodiversitylibrary.org/
Catalog of scanned historical documents on biology and natural history
- pages (and plates) can be browsed, searched, and downloaded
- extensive use of tags for text content (OCR-generated from scans)
- available as OCR text, searchable PDF, or JPEG2000 images

Nearshore Fish Atlas of Alaska; nearshore fish photos
http://www.fakr.noaa.gov/habitat/FishAtlas/speciespage.htm
Images of species caught nearshore
- several images of juveniles (uncommon to see online elsewhere)
- photo gallery part of a large website (atlas) with species information

Biigle
http://www.biigle.de/
Web-based interface for use with biological image data. Flash-based tool for viewing, classifying, and counting features on project dive images

7.2.2. Image sites with user contributions

MorphBank
http://www.morphbank.net/
User-submitted photogallery for animals (forms, appendages)
- custom metadata (annotations) on upload
- museum-type images and data
- previews and full-size downloads

ROSM – Réseau d'organismes sous-marins (Underwater Observers Network)
http://www.rosm.ca/ (in French and English)
User-submitted photo gallery for species profiles of aquatic organisms
- small previews of images and video clips taken in the field
- associated observational data: location, environmental conditions, etc.
- same software also used in websites of aquatic invasive species, sharks

BOLD Systems Taxonomy Browser
http://www.boldsystems.org/views/taxbrowser.php
Images from specimens submitted to DNA barcode analysis
- presents metadata and small image previews of submissions
- offers guides for taking images and submitting images:
  http://www.boldsystems.org/docs/handbook.php

EOL – Encyclopedia of Life
http://www.eol.org/
Web portal aggregator of species information
- users can contribute images and data using LifeDesks
- users may participate in discussion forums
- appointed curators produce content for posting
- images from partners (e.g., WoRMS) are shown with metadata and links

LifeDesks - example project: Marine Biodiversity of British Columbia
http://bcbiodiversity.lifedesks.org/
Biodiversity web projects curated and submitted by users
- modules include image gallery, taxon pages, bibliography
- images as small previews with metadata; originals also available

WoRMS – World Register of Marine Species
http://www.marinespecies.org/photogallery.php
Authoritative taxonomic website, includes a gallery of user-submitted images
- small thumbnails and medium-sized previews
- mixed sources (field and lab images)
- user-editable data on upload (species, title, description, author, contact)
- displays some embedded image metadata (EXIF, GPS, IPTC-XMP)
- taxonomic content curation (verification of species)

CaRMS – Canadian Register of Marine Species
http://www.marinespecies.org/carms/photogallery.php
Regional portal of the World Register, curated by Fisheries and Oceans Canada
- as with WoRMS, users may 1) submit images to the curator for posting, 2) post images on their own, or 3) sign up (email account) to post and edit their image entries

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APPENDIX 1. SUMMARY OF MINIMAL METADATA FIELDS

Annotation fields for photo metadata were presented in Section 2.3 (Metadata). The following fields are suggested as metadata for aquatic science work. More details on the specifications of fields and their usage may be found at: www.photometadata.org, www.metadataworkinggroup.org, and www.iptc.org.

Filename (strongly recommended)
Replace or append initial camera filename with a unique identifier name.

Date created (automatic, default)
Date photo was captured, written by the camera. Assumed to be in local time zone. Date and time are only edited in case of camera clock error (use an Exif editor).

Creator (also known as *Author*) (strongly recommended)
Name of photographer, or when appropriate, of the employer or group. Enter as "Firstname Lastname," with comma as separator between entities e.g.: "John Smith" or "DFO" or "John Smith, DFO." Fields are also available for contact information (optional): *Address, City, State/Province, Postal Code, Country, Phone, E-mail, Website*.

Keywords (strongly recommended)
One or more words providing information on the photo. Terms are separated by a comma. Terms may range from abbreviations and codes to phrases. Example set: "Gadus morhua, cod, Northwest Atlantic, Station 2010-119A, biological sampling, female, mature, survey." The *Keywords* field is one of the most reliable for embedding terms to be read in different software. Some software allows the use of hierarchical (nested) sets, e.g., "species>fish>cod" or "Biological surveys>Mission 2010>Station 119A." Note that hierarchical structures are not always retained in different software; their use is best reserved for advanced catalogs and image data managers.

Copyright status (optional)
Field by default is "unknown." Other choices are "public domain" or "copyrighted." Change only if legal status is clearly known. Other copyright fields are also for legal use.

Title (optional)
A short reference to identify photograph, either as an original file name or a subject, e.g., "DSC-0123.JPG" or "Yellow starfish from fall cruise 2002." This may also be useful for scanned images, to retain the title from original media (not the digital filename). *Title* is not the same as *Headline* (a short journalistic synopsis) or *Description* (see below).

Description (also called *Caption*; optional)
Text summary or comments regarding the content of the photo. May be a phrase or a paragraph, including punctuation. Subjects depicted may be named. Locations may be described (geographical names should be repeated in location fields – see below). Do not use for information that may be placed in contact and copyright fields, e.g., *Creator*.

Location (also known as *Sublocation*; optional)
Geographical name of the site where the photo was taken. This is the fourth-level field in the hierarchy *Location/City/State/Country*. May be used to name a station, or the station may be found in *description* or *keyword*). The other spatial name fields are, in ascending hierarchy:
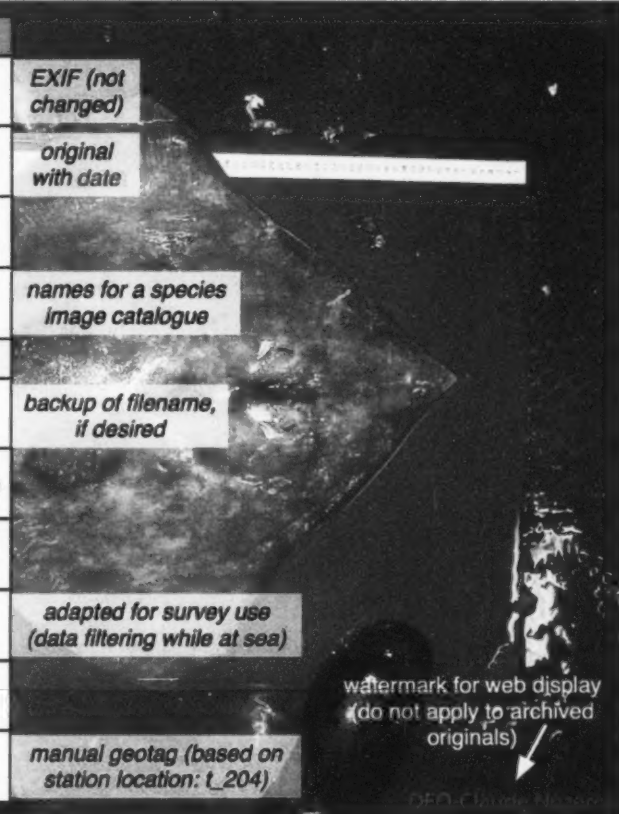
- *City*: city where the photo was taken
- *State/Province:* region where the photo was taken (use initials such as BC, QC)
- *Country*: country name where the photo was taken

GPS (latitude, longitude, altitude)
Exif fields written by geotagging software. May be automatically attributed by date from a GPS track, sublocation name, or manually entered. Note: negative altitude values (for depth) may be entered, but some software may not read or display the negative sign.

recommended		
date created	2007-08-31, 2:04:24 AM	*EXIF (not changed)*
filename	20070831_IMGP1832.JPG	*original with date*
creator	DFO, Claude Nozeres	
keywords	Rajidae, Bathyraja spinicauda, Spinytail skate	*names for a species image catalogue*
optional		
title	_IMGP1832.JPG	*backup of filename, if desired*
creator: email	Claude.Nozeres@dfo-mpo.gc.ca	
description (caption)	Large skate at trawl station 204, released after measuring.	
sublocation	TE-004_2007_t_204	*adapted for survey use (data filtering while at sea)*
copyright status	copyrighted	
GPS Latitude GPS Longitude Map Datum	49,0.7002N 63,12.7998W WGS-84	*manual geotag (based on station location: t_204)*

watermark for web display (do not apply to archived originals)

The above illustration demonstrates minimal metadata fields embedded in an image. Recommended actions include confirming *date*, creating a unique *filename*, entering *creator* name(s) and useful *keywords*. Optional information fields include *title, email, description,* and *sublocation. Copyright status* and a watermark are shown here for file copies in web distribution. Location was used here to assist in sorting data by station. The station name could also have been set as terms in *keywords* or as a phrase in *description*. GPS fields were manually tagged based on location (station coordinates).

APPENDIX 2. SUMMARY OF CONTROLLED VOCABULARY LISTS

Keywords are free-form words to add information in association with photos (see Section 2.3). However, they are more effective to manage when drawn from a predefined list. Several controlled vocabulary lists are already available for scientific collections metadata, while more are in development for biology and image data. The following sources are examples of currently maintained vocabularies. In a best practices scenario, the use of keywords in collections (group-level) and images (object-level) would be drawn from one or more of these sources. For current references on marine science vocabularies and tools, consult the Marine Metadata Interoperability website (http://marinemetadata.org/conventions).

Public vocabularies

Controlled Vocabulary (http://www.controlledvocabulary.com/)
Lists of general photography-related keywords offered for purchase. May be imported into photo metadata editors and managers, e.g., *ExpressionMedia, Bridge, Lightroom, IDimager, AtomicView, Photomechanic*. Website also hosts concise tutorials and resource links concerning the value and use of metadata in images.

GCMD – Global Change Master Directory (http://gcmd.nasa.gov/index.html)
Sets of keyword vocabularies hosted by NASA Earth sciences group. Sets include general terms for oceanography, geographical regions, and biology to enable data discovery. Keywords are hierarchical. Makes use of ISO standards and promotes cross-mapping with other metadata standards (e.g., FGDC, Dublin Core). GCMD science keywords serve the Marine Community Profile (http://www.aodc.org.au/index.php) and are used by DFO for BioChem (oceanography and plankton database) and the *jMetaWriter* editor (see Section 6.7).

ITIS – Integrated Taxonomic Information System (www.itis.gov)
Taxonomic terms of species, each attributed with a numerical code known as the "TSN" (Taxonomic Serial Number). Terms are hierarchical, i.e., follow a taxonomic tree. The linked species terms using TSNs are the principal reference for species websites, including EOL and GBIF, and by data managers at NOAA and DFO.

WoRMS – World Register of Marine Species (http://www.marinespecies.org/)
Note: CaRMS is the Canadian register (http://www.marinespecies.org/carms/index.php). Aquatic species taxonomic terms. Each taxon has a numerical code (AphiaID) and is cross-mapped to a TSN when the taxon is also present in ITIS. Terms are hierarchical by taxonomy. A taxon match tool can output scientific names as SGML compliant for cross-mapping to the FGDC Biological Data Profile. Focusing on marine species, WoRMS covers and verifies global species names (especially of invertebrates) while ITIS emphasizes North American species and includes coverage of terrestrial and aquatic (freshwater) species. At present, DFO uses both ITIS and WoRMS taxonomies.

ASFA Thesaurus – Aquatic Sciences and Fisheries Abstracts
(http://www4.fao.org/asfa/asfa.htm)
Recommended terms and their synonyms for aquatic sciences and fisheries. In use by WAVES, the library document catalog of DFO.

NBII Biocomplexity Thesaurus – National Biological Information Infrastructure
(http://www.nbii.gov/portal/server.pt/community/biocomplexity_thesaurus/578)
Keywords for use in biology, ecology, and environmental sciences. Incorporates former library thesauri of CSA (e.g., aquatic, fisheries, and life sciences). In use by USGS (NBII) and partners such as NCEAS with their *Morpho* metadata editor for EML (Ecological Metadata Language; http://knb.ecoinformatics.org/index.jsp).

MBARI VARS Knowledge Base (http://www.mbari.org/vars/)
Keywords for tagging video footage. In use by MBARI for *VARS* (*Video Annotation Reference System*). The open-source *VARS* software is being revised, with public release expected soon. Information on the current ontology (reference terms) can be consulted at: http://mmisw.org/orr/#http://mmisw.org/ont/mbari/keyword

GBIF Vocabularies – Global Biodiversity Information Facility
(http://vocabularies.gbif.org)
Lists of the vocabularies in use and in development for the GBIF data portal. Emphasis on geographical and taxonomic lists to annotate species occurrence data. Includes cross-mapping with standards DCMI (Dublin Core) for general terms and DWC (Darwin Core) for biology.

Internal (DFO only) vocabularies

BioChem
Plankton and oceanography national database using *Oracle*. Employs a custom vocabulary list, with the taxonomy component derived from ITIS (or WoRMS) and general science keywords coming from GCMD.

ClassActMapper
Dive video analysis software running an *Access* database. Tags for substrate and species.

VideoMiner
Dive video analysis software running an *Access* database. Tags (fields) for species are a controlled set of names from ITIS.

Sablefish Research Surveys (Pacific Region)
Catch survey database using *Microsoft SQL Server* and *Oracle*. Makes use of categories (akin to hierarchical keywords).

APPENDIX 3. METADATA REFERENCE LABELS

The placement of a label in the field of view of an image or a video may serve as a visual cue for tagging after image capture and as a complement to field notes.

Examples for use in photos (A, B) and video (C):
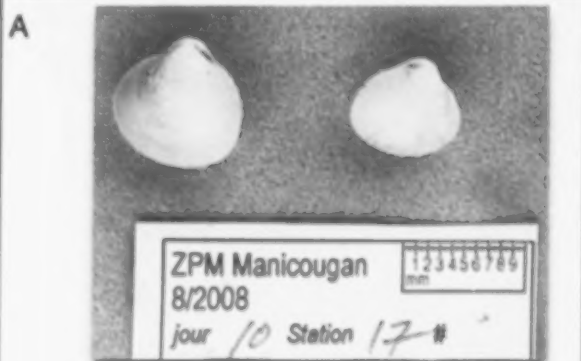
Label with scale bar and notes (cruise, date, station) for later tagging of metadata with specimen images. Label may be conserved with the physical specimen and as tagged image for searching and reference in an image catalog.

Label with ID code and markers (ruler, colour bar) to link specimen to genetic analysis. Image is from the Taxonomy Browser of the Barcode of Life Systems website that also displays the collection metadata (white box) for the photo.

Digital slate (tablet application- *DSLR Slate* on an iPad) to mark the video reference timecode and other project details. Slate screen is displayed at beginning of filming. Timecode is taken as GPS time from the slate and can be synchronized to video.

APPENDIX 4. GUIDELINES FOR STILL IMAGES

For preserving original captures along with edited versions for use in print and web, certain features of images should be known, such as appropriate use, size, and quality (JPG compression). See Section 2.2 for more discussion of image data formats.

Note that the absolute size of a still image is measured in dimensions of horizontal by vertical pixels, rather than pixel density ("300 dpi") or relative size ("8 × 10 in").

Guidelines for recommended still image types:

Type	Mosaic*	Raw	Large	Medium	Web
Use[1]	panoramas, compositions, special edits	archive of camera files	archive of camera or scanner	large screen view	normal web view
Image size[2]	>2000	>2400	>1200	1600×1200	800×600
Print size	Poster or roll paper	Tabloid (11×17 in)	Portrait (8×10 in)	Postcard (5×7 in)	Card (2×3 in)
Format	JPG or TIF	DNG (RAW)	JPG or TIF	JPG	JPG
Colour space[3]	sRGB	— (lossless)	sRGB	sRGB	sRGB
Quality[4] (JPG)	High	— (lossless)	High	Basic	Basic
File size[5] (expected)	10–200 MB	10–30 MB	1–10 MB	0.1–1 MB	50 KB

[1] General description
[2] Resolution (image size) in number of pixels
[3] Camera default is sRGB in JPG, although RAW files may be tagged as AdobeRGB
[4] JPG compression settings: high (superfine or fine), basic (normal)
[5] Varies depending on use of compression
* Mosaics merge several images to produce a larger, composite image file

APPENDIX 5. GEOGRAPHY REFERENCE STANDARDS

Lorne Collicut, DFO Pacific Region

PacFish Reference Data Standards (24 Sept. 2010)
Geography – Latitude/Longitude Standard

abridged and adapted from Version 4

Fisheries and Oceans Canada

PacFish
Reference Data Standards

Geography – Latitude/Longitude Standard

Date: September 24, 2010
Version: 4

1. Scope of this document

This document outlines the data standard for Latitude and Longitude data for the purposes of data collection, exchange and the digital display of raw data records (not derived map products). It does not imply or specify any standards for technology-specific data storage or processing in a database or GIS.

2. Basis for Standard

This standard is based on the ISO 6709;2008 Geo Point Standard. In this International Standard, geographic point location shall be represented by four elements:

- coordinate representing "x" horizontal position such as latitude;
- coordinate representing "y" horizontal position such as longitude;
- for 3-dimensional point locations, a value representing vertical position through either height or depth;
- a coordinate reference system (CRS) identification

3. Representation of latitude and longitude in User Interfaces

To retain consistency of data display across different DFO systems, it is recommended that all custom developed systems display latitude and longitude data using the following format:

- The order of the fields should be latitude, longitude, vertical postion (if given), coordinate reference system (if space allows)

- Latitude/Longitude:
  - o display in degrees, minutes, seconds and decimal seconds (to 2 decimal places) format;
  - o degree, minute and second units should be identified with symbols:
    - °, ' and " (ISO/IEC 8859-1, codes 1100, 0600, and 1008 Hex, respectively);
    - user interfaces unable to use the recommended symbols can alternatively use 'd' for degrees, 'm' for minutes and 's' for seconds.
    - the symbols should follow their value;
    - there should be no spaces between degree, minute and second values;
    - latitude hemisphere north or south should be indicated with the letter N or S, respectively (ISO/IEC 8859-1, codes 0314 and 0503 Hex, respectively). There should be no space between the latitude value and its hemisphere indicator;

- longitude hemisphere east or west should be indicated with the letter E or W, respectively (ISO/IEC 8859-1; codes 0405 and 0507 Hex, respectively). There should be no space between the longitude value and its hemisphere indicator;

- Vertical Position (Depth or Height):
  o Vertical position unit of measurements should identified with a symbol such as 'm' for metres. The symbol should follow the value and there should be no space between the value and its unit symbol;
  o When possible, the reference surface should be displayed.

- Coordinate Reference System (CRS):
  o Where space allows the CRS should be displayed with each latitude and longitude. If space is inadequate, the CRS should be available to the user somewhere in the interface.

EXAMPLE: 50°40'46.46"N   124°48'26.53"W   45m   WGS 84

4. Representation of latitude and longitude for collection and data exchange

This section specifies the standard for representing point data during data collection and exchange between DFO and external parties or between internal DFO parties. Its scope is limited to exchanges of data via non-binary mechanisms (typically via CSV or XML files but also including commercial formats such as Excel or MS Access). The scope does not include data transfer via specialized GIS formats such as ESRI Shapefiles.

The standard format for collection and data exchange of point data is outlined below.

Format

- Latitude, longitude, depth and CRS data should appear in separate fields. The exact format to be used in data transfer should be specified in a Data Exchange Specification developed for the data collection program. All formats should respect the standards outlined in this document.

Latitude

- Latitude shall be specified in Degrees and decimal degrees, usually to 4 decimal places (see Accuracy/Precision section below): DD.DDDD. The first two digits of the latitude string shall represent degrees. Subsequent digits shall represent decimal fractions.
- Latitude on or north of the equator shall be designated as a positive value (do not include the '+' sign). Latitude south of the equator shall be designated using a minus sign (-).

Longitude

- Longitude shall be specified in degrees and decimal degrees, usually to 4 decimal places (see Accuracy/Precision section below): DDD.DDDD. The first three digits of the longitude string shall represent degrees. Subsequent digits shall represent decimal fractions.
- Longitude on or east of the prime meridian shall be designated by a positive value (do not include the plus sign '+'). Longitude west of the prime meridian shall be designated using a minus sign '-'.

Vertical Position (Depth or Height)

- The representation of vertical position is optional.
- If a vertical position is given, the reference surface from which position is measured must be supplied. Since most vertical measurements associated with fisheries data are depth, the most common reference surfaces used are related to the surface of the ocean. The allowable values are:
- HOT (Height of Tide): the current level of the sea at the time, date and location where the depth measurement occurred. This value covers depth measurements made relative to the current height of the surface of the sea via sounder, diver pressure gauges, tow wire angle, manual sounding line etc.
- LLWLT (Lower Low Water, Large Tide): measurements standardized to be relative to the lower low water, large tide values used as Chart datum on Canadian Hydrographic Service charts (reference: http://www.waterlevels.gc.ca/english/VerticalDatums.shtml).
- MLLW (Mean Lower Low Water): measurements standardized to be relative to the mean lower low water values used as Chart datum on US charts (reference: http://tidesandcurrents.noaa.gov/datum_options.html).
- LAT (Lowest Astronomical Tide): The LAT is the lowest level of tide that can be expected to occur under average meteorological conditions and under any combination of astronomical conditions. This is the international standard which CHS charts will be adopting in the next few years.
- Vertical positions above the reference surface should be positive values (do not include the '+' sign).
- Vertical positions below the reference surface should be negative values (the '-' sign must be supplied).
- If a vertical position is given, measurement units must be provided and should appear in a separate field directly following the value. Metres (m) is the recommended unit of measurement.
- It is highly recommended that vertical position measurements taken from relative reference surfaces such as Height of Tide be accompanied by the date and time to permit future conversion to standardized reference surfaces such as Lowest Astronomical Tide.

Coordinate Reference System (CRS)

The recommended CRS is WGS84. NAD83 will be supported as an alternative. Additional coordinate reference systems may also be supported by special arrangement. The receiving data custodian should be consulted to confirm their ability to support additional referencing systems.

Regardless of which CRS is used, it is mandatory that the CRS be clearly identified for all point data. The recommended means of identification is to include a CRS identifier with each data point. This method is particularly well suited to 'flat' (non-hierarchical) formats such as a comma delimited (CSV) ASCII file. Hierarchical formats such as XML allow a single CRS to be identified for an entire data set.

Data Accuracy/Precision

For the purposes of this document Accuracy is defined as 'the degree to which point data matches true or accepted values' and Precision is defined as 'the level measurement and exactness used to collect/capture/record the data'. While both concepts are important to data quality, this document will focus primarily on recommendations around data precision, in particular around the specification of how many decimal places to use when recording coordinates.

The following table outlines the relationship between the number of decimal places collected for point data and the spatial precision achieved.

Decimal Places	Degrees	Distance*
0	1.0	111 km
1	0.1	11.1 km
2	0.01	1.11 km
3	0.001	111 m
4	0.0001	11.1 m
5	0.00001	1.11 m
6	0.000001	0.111 m
7	0.0000001	1.11 cm
8	0.00000001	1.11 mm

Note that these values were calculated at the equator. For Pacific Region waters the actual distance values would be smaller (more precise) then listed above.

The degree of precision to which point data should be collected will be left to the data collection program but this document offers the following recommendations:

- Whenever possible, data collection programs should attempt to specify the precision required for their purposes and use the table above to determine the decimal places required.

- If it's not possible to determine a target precision programs can use the following general rule of thumb. It would be adequate to collect most fisheries data to 4 decimal places, which gives a resolution of better than 11.1m in Pacific Region. This value corresponds to the generally accepted maximum accuracy of most commercial GPS devices of 10m.

Examples

Comma delimited flat file format with Latitude, Longitude, Depth, Depth Units, Depth Reference Surface, CRS:

   54.2036,-124.5337,45,m,HOT,WGS_84

Comma delimited flat file format with Latitude, Longitude, (no depth), CRS:

   54.2036,-124.5337,WGS_84

5. Approval History

This standard was approved by the PacFish Data Standards Committee on September 13, 2010.

6. References

ISO 6709 2008 can be found at http://en.wikipedia.org/wiki/ISO_6709

Canadian Hydrographic Service information on tidal datums:
http://www.waterlevels.gc.ca/english/VerticalDatums.shtml

US National Oceanic and Atmospheric Administration information on tidal datums:
http://tidesandcurrents.noaa.gov/datum_options.html

Discussion on horizontal and vertical datums:
http://en.wikipedia.org/wiki/Datum_%28geodesy%29

Estimated precision of latitude/longitude: http://en.wikipedia.org/wiki/Decimal_degrees

APPENDIX 6. GUIDELINES FOR MINIMAL METADATA

Adapted from:

Guidelines for the Minimal Metadata for Digital Images for Digital Images 2010-12-15

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1.0 Metadata requirements for digital assets

Metadata, by a simple definition, is data about data. For the purposes of digital imaging, it provides structured information about the characteristics of the image object. There are three types of metadata:

1. Technical: Details that the image acquisition system attaches to the image.
2. Content: The data that you manually add to an image.
3. Curatorial: Data related to the copyright and distribution.

Metadata has become a powerful tool for management, organization, and discoverability of digital photos. As the Department's image assets are rapidly growing, it is important that those who manage digital media also manage the content related to that digital media. A minimal set of metadata elements required for all image data has been developed by the Department as well as guidelines on how to populate each element.

1.1 Terms related to metadata

A list of acronyms and their definitions are provided below. Click on the provided website links for more information.

DCMI Dublin Core Metadata Initiative. http://dublincore.org/

EXIF Exchangeable Image File Format, a standard for storing technical interchange information in image files. http://www.exif.org/

GCMD Global Change Master Directory thesaurus – a general science vocabulary. http://gcmd.nasa.gov/Resources/valids/index.html

IPTC Standards developed by the International Press Telecommunications Council. For content and curatorial purposes. http://www.iptc.org/site/Home/

ISO International Organization for Standardization. http://www.iso.org/iso/home.html Prepares guidelines for displaying timestamp, datestamp, and geospatial information.

MCP Marine Community Profile
http://marinemetadata.org/references/marineprofile19115

PSD Photoshop Document: a graphics format for advanced image editing with layers. http://www.photoshop.com/

XMP Extensible Metadata Platform: an extensible markup language used to store image metadata. Commonly used for still images (JPG, TIF, PSD, RAW); occasionally may also be applied to graphics and video files. http://www.adobe.com/products/xmp/

1.2 Digital image file formats and existing metadata standards

Digital images and videos are stored in a variety of file formats such as JPG, JP2, TIFF, BMP, GIF, EPS, PDF, PSD, PNG, MPEG, AVI, and MOV. The most common format used by digital cameras is the JPEG (.jpg filename extension). Within these files, there exists a number of established metadata standards currently used by the digital photographic industry.

One standard of metadata that is automatically captured by your camera and stored in your pictures is called EXIF data or Exchangeable Image File Format. Other standards of metadata allow users to add their own descriptive data to a photo. The most common standards are IPTC (International Press Telecommunications Council) and Adobe's XMP (Extensible Metadata Platform) that have published specifications.
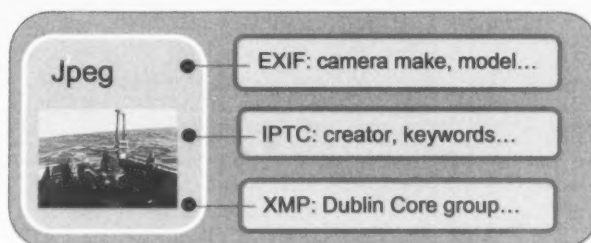
Note that other standards go beyond IPTC-XMP, but may be proprietary to specific software, tagging for special features in the image, such as face recognition, location, ratings, and labels. Adobe, Nikon, Microsoft, Apple, and Google all have examples of software that apply internal (proprietary) standards to images.

As the Department also collects geo-referenced image data, the metadata that comply with the ISO 19115: Marine Community Profile standards are discussed here.

1.2.1 EXIF

EXIF stands for Exchangeable Image File Format. EXIF elements are default fields captured in the digital image by photographic or videographic or scanner devices. The information captured will depend on the manufacturer of the camera, but usually the data recorded will relate to the camera model, the time and date of capture, image exposure conditions, camera and lens settings. Global Positioning System (GPS) location data such as latitude, longitude, elevation, and orientation may also be recorded to the image file. Most cameras do not have an internal GPS, or may not be connected to an external receiver during the capture. In these cases, software tools such as the freeware, *GeoSetter* (http://www.geosetter.de/en/), or Google's image editor, *Picasa* (http://picasa.google.com/), are available to embed the geographic location information in the EXIF metadata file.

Note that some software tools avoid writing to EXIF after capture, but instead write "shadow" GPS fields along with IPTC-XMP so as not to modify (and risk corrupting) the original EXIF data. The GPS data is then seen in XMP, but not in EXIF headers.

EXIF data can be viewed with Microsoft Desktop Windows (left) under the image file properties. Other advanced file browser software such Adobe *Bridge CS5* (example shown below right) allows you to view detailed metadata and edit the fields.

1.2.2 IPTC

The IPTC standard (see http://www.iptc.org/site/Home/) was developed in the 1970s by the International Press Telecommunications Council for exchanging information between news organizations. In 1990, IPTC developed a standard for the exchange of media types that included photos. A couple years later, Adobe developed new technology to imbed the IPTC standard elements into the header section of image files. Later, in 2004, IPTC and Adobe worked together to incorporate the IPTC header into a newly developed XMP framework (presented below) to form the "IPTC Core Schema for XMP" standard. Note that, as with all image metadata, editing the data in this header does not affect the image data.

1.2.3 XMP specification

XMP (Extensible Metadata Platform) is the newest standard introduced in September 2001 by Adobe. Adobe describes it as a labelling technology that allows you to embed XML-formatted information into the file itself or as a separate companion (sidecar) file (http://www.adobe.com/products/xmp/). The file format closely associated with XMP is

the RAW format. Because proprietary RAW image files are not modified after capture, the XML information must be held in a sidecar file (the XMP). Standard images such as JPEG, TIFF, and PSD have the XMP information written into their file headers, while other formats for graphics and videos files (e.g., BMP, AVI) also require XMP companions if the file is to hold image metadata. The most common metadata tags recorded in XMP data are those from the Dublin Core Metadata Initiative (DCMI) (see http://dublincore.org/). The Dublin Core group is a simplified list of broad and generic elements used for describing resources. The DC group includes 15 elements: contributor, coverage, creator, date, description, format, identifier, language, publisher, relation, rights, source, subject, title, and type. Adobe also defined the use of XMP to hold image editing metadata (processing instructions), as is required for RAW images. However, in standard images such as JPEG, these processing instructions are not often readable outside of Adobe software (*Bridge, Photoshop, Lightroom*).

Besides Adobe software, other popular products, such as Microsoft *Vista* and *Windows 7*, support the reading and writing of XMP metadata. When you tag a JPEG or TIFF photo with keywords in Windows *Vista* or Adobe *Photoshop*, those tags are stored directly in the file as metadata. XMP also facilitates the exchange of metadata, meaning you can save metadata from one file as a template and then import the metadata into other files.

1.2.4 ISO 19115 Marine Community Profile (MCP) for geographic data

This standard consists of metadata elements that meet the needs of the marine community for the documentation and discovery of marine resources. Fisheries and Oceans Canada (DFO) has built a Java application tool called *jMetaWriter2* (Beta 5.06 6/10/2010) to create geospatial metadata that complies with the ISO 19115: MCP. It can be downloaded from the DFO intranet (internal access) website: http://marbiod11/OSD_Web/FOSDI/FOSDI.shtml. A user guide is available: http://marbiod11/OSD_Web/FOSDI/jMW2_Documentation/index-eng.html. In this software, the user must complete the tab fields that appear in red as they are considered the mandatory elements for the ISO 19115 MCP. These mandatory elements include file identifier, date stamp, language, contact information, language, citation, description, theme keywords, place keywords, distributor name, distributor format, and their associated subfields.

The mandatory element of "theme keywords" is populated from a controlled list of items from the Global Change Master Directory (GCMD) thesaurus (see http://gcmd.nasa.gov/Resources/valids/index.html). The "place keywords" built into this software contain a controlled list of large freshwater lakes as well as general regions of the Arctic, North Atlantic, and North Pacific oceans as provided in the DFO place names dictionary (English, French).

3.0 The Minimal Set of Metadata Elements

As interoperability is paramount in metadata implementation principles, it is important that a core set of minimal metadata elements are established. The minimal set of metadata elements chosen is based on the elements of the ISO MCP, XMP specification, EXIF, and IPTC standards.

Minimal set
of metadata
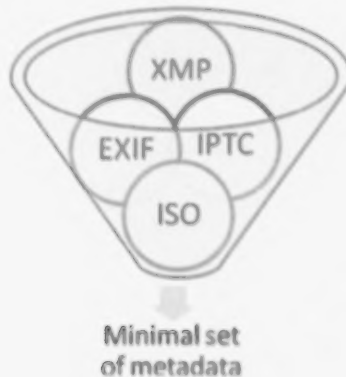
According to the Metadata Working Group 2009 (http://metadataworkinggroup.org/), four metadata elements can be crosswalked as equivalent elements in XMP specification, EXIF and IPTC. The DFO *jMetaWriter2* mandatory ISO 19115 MCP elements have been included in the crosswalk table:

Jmetawriter 2 mandatory elements	Dublin Core (XMP)	IPTC	EXIF
date Stamp	dc: date	date/time	date/time
contact Information	dc: creator, dc: contributor	contact/creator	artist
description: Abstract	dc: description	description	description
distributor name	dc: rights	copyright	copyright

Official languages of the Government of Canada are used when populating the metadata elements for use on a website.

Legend to the Metadata Elements
The description of the minimal metadata elements is formatted as follows:

Element Name
Instructions on how the field should be populated.
    Subfields
    Instructions on how the subfield should be populated.
Note: Add any special notes relevant to the population of the metadata element.

Date/Time Created
This field should contain the date and time when the image was recorded. The format of YYYY-MM-DD hh:mm:ss and TZD (time zone) is the standard.
Note: The EXIF date/time element contains the local time, but the time zone is contained in the GPSTimeStamp field, which is specified in UTC. XMP includes a TZD designator in its date/time field.

Date/Time Modified
This field should contain the date and time when the image was modified. The format YYYY-MM-DD hh:mm:ss and TZD (time zone) is the standard.
Note: The EXIF date/time element contains the local time, but the time zone is contained in the GPSTimeStamp field, which is specified in UTC. XMP includes a TZD designator in its date/time field.

Creator Name/Organization
This field identifies the person or organization responsible for creating the digital media.

    Position/Title
    This field contains the job title of the person who created the digital media. For DFO employees this should include the department division.

    Address, City, State/Province, Zip/Postal code
    Enter the full address of the person or organization who created the digital media.

    Country
    Enter the country name of the person or organization who created the digital media.

    Phone
    Use the format 555-555-5555

    Email address
    Enter the email address of the person or organization who created the digital media.

    Description
    A short, user-defined, textual description of the content of the resource.

Copyright

This field should contain any necessary copyright notice for claiming the intellectual property and indicate whether the status of the property be public, copyrighted, or unknown. See http://www.dfo-mpo.gc.ca/notices-avis-eng.htm#1 for an example of a full notice of copyright and permission to use.
Note: Several software versions may provide all or one of such subfields as Copyright status, Copyright notice, Rights Usage Terms.

Keywords

This field should be populated by a controlled vocabulary of theme and place keywords that specify the content and location of the resource. In keeping with the DFO jMetaWriter 2 mandatory ISO 19115 MCP elements theme, keywords are to be used from the Global Change Master Directory (GCMD) thesaurus (see http://gcmd.nasa.gov/Resources/valids/index.html or GCMD Keywords Excel file). To identify a species, give the full name and common name of the organism to the lowest level taxon to which the organism can be identified.

Place keywords are to be used from the Department of Fisheries and Oceans official area list (English, French). Each keyword should be separated by a comma. Note that some software is case-sensitive in their reading of keywords, e.g. salmon vs. Salmon.

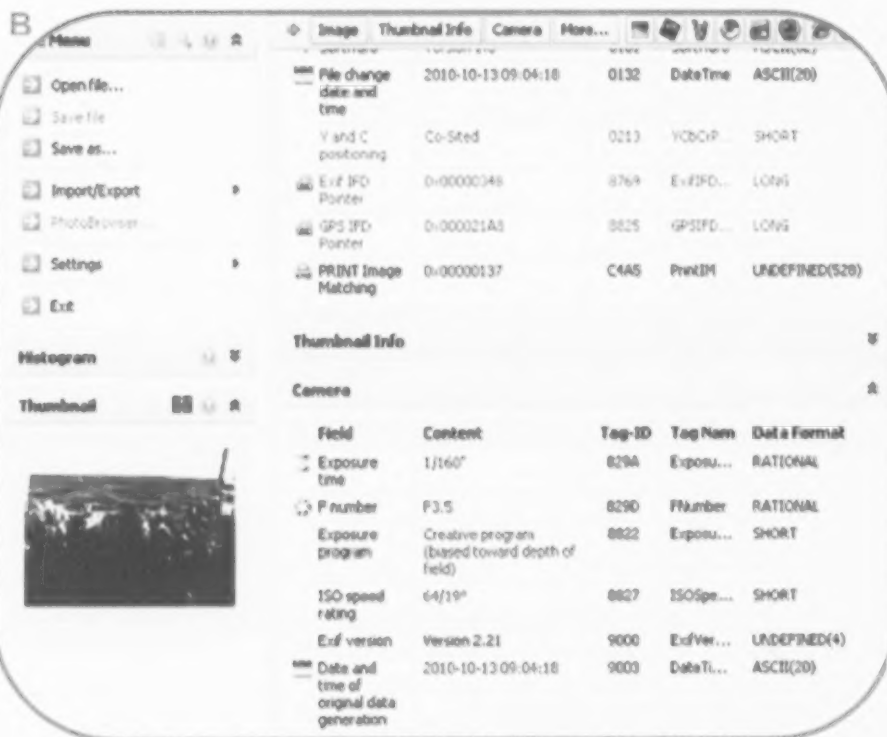| Minimal set of metadata elements	Jmetawriter 2 mandatory elements
Keywords	Theme keywords (GCMD) Place keywords (DFO area list)
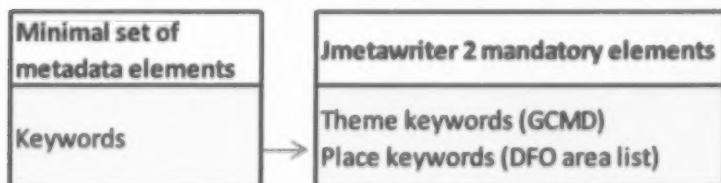
Global Positioning System: GPS

Geo-referenced data about where the image has been created. The values entered in this field should be latitude and longitude values and their corresponding north, south, east or west reference.
*Note: This element is not mandatory for images. It can be created by using specialized software that geotags a digital image.*

4.0 How to: Populate a JPEG with metadata elements

In this scenario, two organizational and image browsing applications are used to enter the minimal metadata elements. Pictured in the following figures are screen shots of Adobe *Bridge CS5* (A) and *PhotoME* (B). Adobe *Bridge CS5* is included with all Adobe CS5 applications. (http://www.adobe.com/products/creativesuite/bridge/). *PhotoME* is freeware found at http://www.photome.de/download_en.html).

First, the date created and date modified are displayed as captured by the image acquisition system in *Bridge CS5* (A) and *PhotoME* (B).

Next, the **creator**, **copyright**, **description**, and **keywords** can be added manually in *Bridge* CS5 (A) and *PhotoME* (B) (Note that these elements can also be filled in bulk).
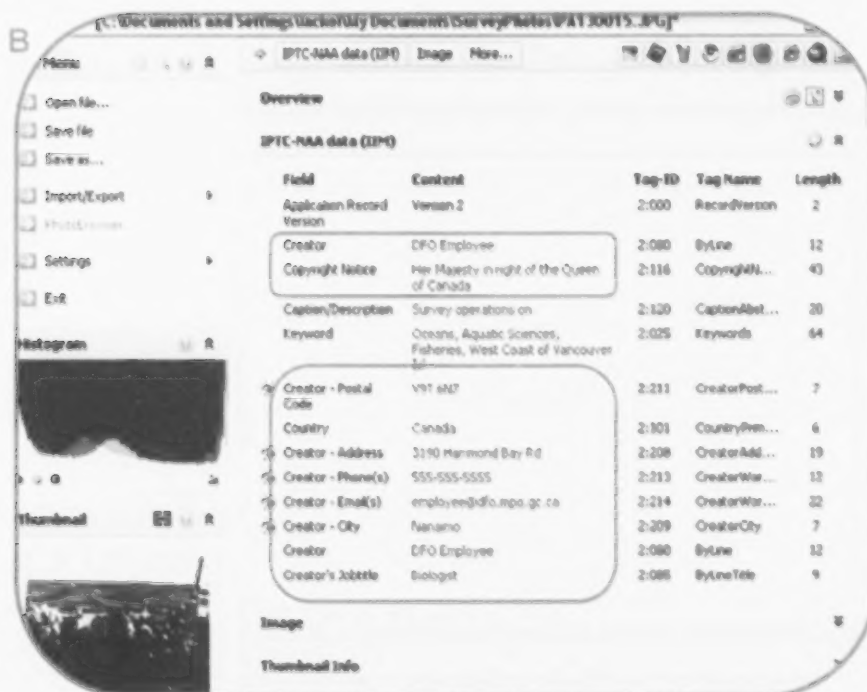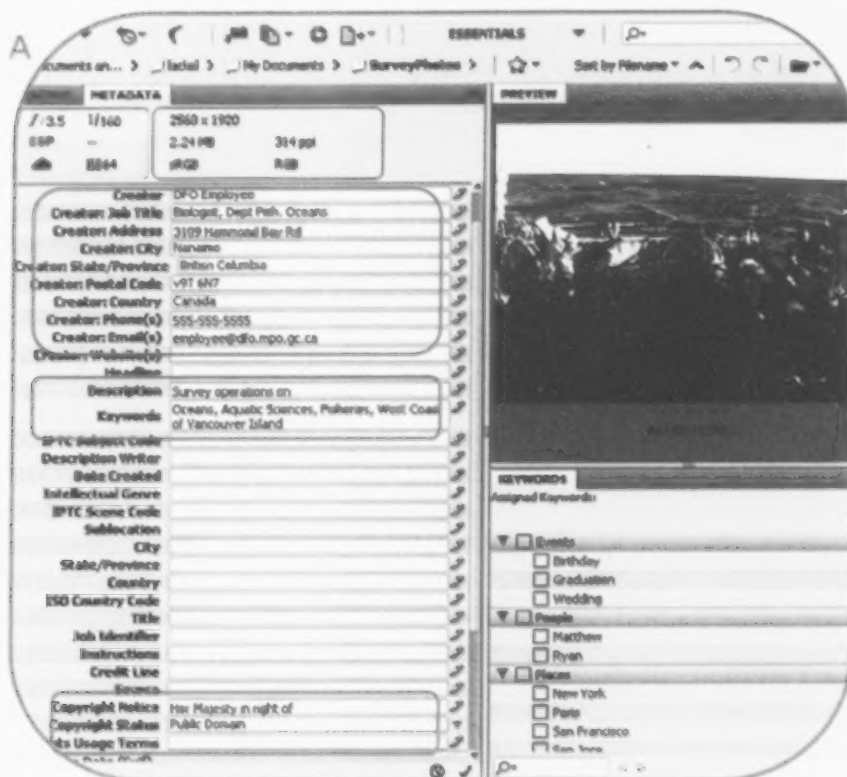
4.1 How to: Populate a JPEG with GPS coordinates using the freeware *Picasa*

Picasa 3.8 can be used to geotag a photo. The instructions and demo video are found at http://picasa.google.com/support/bin/answer.py?answer=161869 and provided in the figure below.

The images now contain latitudinal and longitudinal values.